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THE Popular Science Review.

A QUARTERLY MISCELLANY OF ENTERTAINING & INSTRUCTIVE ARTICLES ON SCIENTIFIC SUBJECTS.

EDITED BY JAMES SAMUELSON,

AUTHOR OF "THE EARTHWORM AND HOUSEFLY," "HONEY-BEE," ETC.

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THE PHOSPHORESCENCE OF THE SEA.

BY A. DE QUATREFAGES, MEMBER OF THE INSTITUTE OF FRANCE,
PROFESSOR AT THE MUSEUM AT PARIS,
TRANSLATED (WITH EXPLANATORY NOTES) BY THE EDITOR.

OF all the interesting, marvellous, or fantastic spectacles presented by the sea, one of the most remarkable is, undoubtedly, that phosphorescence in which the opposing elements *par excellence*, fire and water, appear to be blended in intimate association.

From time immemorial, too, it has arrested the attention and vividly excited the imagination of those who were enabled to observe it on a sufficiently extensive scale. There never was a sailor who, in transcribing the narrative of his wanderings, has failed to comment upon those intertropical seas in which phosphorescence is revealed in all its splendour, and where the vessel seems to plough its way through one vast sheet of flame, leaving behind it a fiery track; whilst the great zoophytes and mollusca, united in colonies and rolling beneath the waves, suggest to the observer the idea of glowing cannon-balls or masses of incandescent metal.

But is it not possible that some little exaggeration may have crept into the descriptions of these brilliant tableaux?

One would fain be tempted to believe so; and yet the reality, as it may be observed even in our temperate seas, induces me to give credence to the testimony of these eye-witnesses. But not having had the opportunity of looking upon the phenomenon developed to perfection, and only desiring to speak of what I myself witnessed, it is my intention, in the present paper, to restrict myself to an account of some of my own observations, and of some experiments that I have undertaken in order to become satisfied concerning the cause of marine phosphorescence, as exhibited in our great European harbours.

1. Description of the Phenomenon.

Most of the authors who have applied themselves to the study of marine phosphorescence, have treated only of what may be termed *diffused* or *general* phosphorescence. In this

case the light appears to suffuse the whole surface of the water; but it is necessary to distinguish between this and another phase, in which the light is visible only in isolated patches, having no connection with one another, and where the liquid itself presents no appearance of luminosity: the latter we shall denominate *partial phosphorescence*.

The first mode of phosphorescence is visible in almost every part of the Mediterranean Sea. On the shores of the ocean it has been observed at Havre, Dieppe, Ostend, and doubtless in all seaports and tranquil basins. I have myself noticed it at La Rochelle, Boulogne, &c.; but it was at the place last-named that I studied it with the closest attention. Here the phosphorescence, which is very conspicuous in the "port," properly so called, in the dry-dock, and especially at the oyster-beds,* becomes less perceptible between the two jetties, and entirely disappears where the fresh waters of the Liane intermingle with those of the sea.

The following are some of the observations made by me in the locality just named, and which being, so to speak, the highway between France and England, will doubtless be well known to many of the readers of this Journal.

However favourable the circumstances may otherwise have been for the production of the phenomenon, perfectly tranquil water was *always* completely dark. A concussion, no matter how feeble, was requisite for the manifestation of light. A grain of sand thrown upon the dark surface gave rise to a luminous blot, and the undulations proceeding from this centre were perceptible as luminous circles, becoming larger and larger, but at the same time more and more faint in proportion to their distance; just as the concentric undulations themselves became more feeble as they receded from the centre. A stone as large as one's fist produced similar effects, but in a more marked degree; and then, moreover, the drops resulting from the splash resembled the sparks flying from an anvil on which the blacksmith is welding a bar of iron raised to a white heat. Tranquillity being again restored to the surface, all returns to obscurity, and the keenest observer could detect nothing that would lead him to suppose that this water, dark even to blackness, was ready at any moment to burst into coruscations, and recognize by its phosphorescent play, the descent upon its surface even of the minutest fragment of straw. The oyster-bed was always encircled by a phosphorescent belt, arising from the constant undulations of the sea, which broke upon the beach in gentle ripples. Seen from a distance, these little waves, barely four inches in height,

* According to the project, recently adopted, for the excavation of a wet-dock, the oyster-beds will disappear: perhaps they are no longer in existence.

presented a dead white tint, which might have been mistaken for foam illuminated by moonlight; but on a nearer approach their appearance changed, and they seemed to be crowned with a faint bluish flame, comparable to that proceeding from a lighted bowl of punch. When they burst, the illumination, even as it appeared to a person standing at the water's edge, became whiter and more vivid, and the undulations often resembled waves of molten lead or iron, bespangled all over with innumerable sparks of a brilliant white, or whitish-green hue. A similar appearance was presented on the sand after the wavelets had burst; for they imparted to it a uniformly white and luminous tint, from which there appeared to spring myriads of scintillations more vivid and intense than the luminous ground. As the water became absorbed by the sand, its limits were clearly defined by a bright luminous cordon or band, which indicated the extent to which it had spread upon the shore.

When the hand was plunged into these fiery waves, and then withdrawn, it was at first completely luminous; but after a few seconds there only remained a number of glistening specks, which were, however, tolerably persistent. Water drawn from the beach, and poured from a certain height, exactly resembled molten lead, and the splashing drops presented precisely the same appearance. This luminous display was of considerable duration, and it was sufficiently brilliant to deceive the instinct of animals. During one of these nocturnal rambles, in which I was accompanied by a friend* who was aiding me in my experiments, the watch-dog belonging to the oyster-bed came bounding towards us, and barked loudly, thinking, no doubt, that he had to deal with robbers. We repulsed him with the contents of our brine-can, and in order to escape from this water, which he mistook for fire, he at once fled, and contented himself with threatening us at a respectful distance.

Another circumstance whereby we may recognize that *movement* is necessary for the manifestation of these luminous phenomena, is the following: That portion of the beach from which the tide has just receded appears, as one approaches it, to be quite free from phosphorescence; but when trodden upon, this is found not to be the case, for the concussion caused by the foot in walking, produces exactly the same effect as the stone which is flung into the tranquil water. The very ground appears to kindle under the steps of the pedestrian, and the fine gravel

* M. Bouchard-Chantereaux, one of those rare examples of the class of men who, in the isolation of the provinces, are still capable of fostering an ardent love for science, and to whom justice is seldom rendered by the learned community; for, satisfied with the acquisition of knowledge, they publish but few, if any, of the results of their arduous labours and investigations.

presents the aspect of red-hot cinders; this appearance, under the most favourable circumstances, extending at times to a distance of some inches from the impression left by the foot.

Such are the chief phenomena that accompany general or diffused phosphorescence; of a totally distinct character, however, are those which I ascribe to partial phosphorescence. In this there is nothing to remind one of the uniform tint that conveys an idea of the transmutation of the very liquid itself into the fiery element. The light is emitted only in isolated points, absolute scintillations, which usually appear and disappear with great rapidity. However numerous these sparks may be, they never by any chance coalesce; they stand out clearly from the dark background formed by the surface of the water, and their brilliancy is considerably heightened by the striking contrast. The spectacle which they produce is often a grand one. In the little channel known as the "Sund de Chausez," I have seen, on a dark night, each stroke of the oar kindle, as it were, myriads of stars, and the wake of the craft appeared in a manner besprinkled with diamonds.

At Bréhat, St. Malo, St. Vaust, and at Biarritz, I have collected similar data, and believe that I may unhesitatingly say that in those unsheltered roadsteads on the coast, which are entirely exposed to the free action of the waves, this, if not the only one, is at least the most frequent mode of phosphorescence.

It is with this kind of phosphorescence that I associate that of marine plants, so far as it has presented itself to my observation under certain circumstances; more especially as I witnessed it in the narrow channels which separate the rocks and granitic islets of our small archipelagos in Brittany.

There I have seen entire masses of fucus kindle, as it were, when roughly shaken; but even then the luminosity presented itself in isolated points, which the eye could easily distinguish. Under no circumstances did either stems or leaves exhibit the uniform glow of a metal raised to a white heat, and the water which drained from the plants was perfectly dark.

2. Causes of the Phosphorescence.

It may readily be conceived that a phenomenon so remarkable as that which is occupying our attention should early have attracted the notice both of the savant as well as of the superficial observer, and owing to that tendency of the human mind which prompts it to search after causes, before even it is conversant with the nature of effects, explanations could not fail to abound. This is precisely what has happened. It is almost needless to say that many of these solutions, hazarded at the first blush, and based upon appearances only, would

necessarily be, as they have indeed turned out, completely inaccurate.

Upon these, therefore, we shall not dwell, for it would be foreign to our object; but shall confine ourselves to the account of some of the more lucid explanations that have been attempted by various authors.

Ancient navigators appear to have attributed the light which is developed on the surface of the water to what may be termed "ordinary causes," and they believed it to be due to various atmospheric phenomena. To them, phosphorescence was the *meteor of the sea*. The foundation of this idea may be traced in the writings of some savans who have endeavoured to account for phosphorescence by purely physical action. Abbé Nollet, for example, sees in it nothing more than a modification of electrical phenomena; Bajon refers it to a disengagement of electricity, occasioned by the friction of the vessel against the waves; Tingry compares it to the *fluorescence of the diamond*, and thinks that the sea absorbs solar light during the day, which is again liberated at night.

Side by side with these physical theories may be placed some chemical hypotheses, equally void of foundation; amongst which may be reckoned those which attribute phosphorescence to "phosphoric fires," to the ignition of bubbles of hydrogen bursting at the surface of the water, &c. &c.

Another explanation of a more rational character, and probably in many cases the correct one, is that which traces the phosphorescence of the sea to the decomposition of various animal substances, more especially to that of the flesh of *fishes and cetacea*. This theory, propounded by Commerson in the manuscripts which are deposited in the library of the Museum of Paris, has reckoned amongst its advocates Bory St. Vincent, Oken, and others. As early, however, as the commencement of the last century, accurate observations had been made on the subject, and the evidence of noted travellers, together with that of eminent naturalists and physiologists, soon placed it beyond a doubt, that a great number of marine animals possess *during life* the attribute of luminosity,—the property of emitting light.

As far back as the year 1705, *Viviani*, Professor of Natural History at Genoa, had discovered in the environs of that city, and had described in a memoir devoted to the subject, as many as fourteen species of luminous animalculæ. To their presence he attributed the phosphorescence of the seas of his country.

Again, *Spallanzani* having dissolved in milk the luminous mucosity that flows from the Medusæ,* thereby rendered the

* Jelly-fishes.

first-named liquid luminous to such a degree, that he was enabled to read by the light emitted from a cupful of it.

Scharr having established the existence of phosphorescence in certain flexible polyparies, attributed to these the phenomenon in general.

Vianelli referred it to a species of Nereid;* *Rigaut*, to an animalcule at present known as "Noctiluca," which we shall consider in detail hereafter; *Henderson* to the Scyllari and Salpæ; that is to say, to Crustacea and Mollusca; and so on.

In our day everything tends to prove that the sea possesses its *phosphorescent fauna*, as does the land. Catalogues of both have been published, and will be found at the end of this paper.

That of the phosphorescent marine invertebrates was no doubt complete when it was prepared by the learned Professor (Van Beneden) at the University of Louvain, but this is certainly the case no longer. The more marine animals are studied, the more numerous are found to be those which possess the light-emitting property. I could, from my own observations, add to this list at least two or three species of Polynoë; one or two species of Syllis,† some species of an allied genus, some Crustacea, two or three species of Ophiura,‡ &c. &c.

And now, let us ask, how much of the phosphorescence of the ocean is due to the aggregation of all these forms? Undoubtedly the major portion—ay, perhaps it is to this alone that the more magnificent phases of the phenomenon must be attributed.

This assertion may, perhaps, appear strange to those who judge of the spectacle presented at sea by what they have been enabled to witness on land arising from similar causes; for there, neither Lampyris, Fulgora, nor Elater,§ has transformed the greensward into a flaming prairie, nor do these insects convert the bushes into blazing underwood.

But the sea is far more prolific than earth and air together, and produces its thousands for one that is created and nourished by the latter; as though it would justify, even in our days, the old fable in which it is designated the first parent of all living things.

In none of the observations that I have myself made on this phosphorescence,—in none of the experiments that I have tried for the purpose of testing the accuracy of my views, have I ever discovered ought but animals, and those, *living animals*. At

* A swimming worm.

† Polynoë and Syllis are also natant worms.

‡ Brittle stars.

§ *Lampyris*, the glow-worm; *Fulgora*, the lantern-fly; *Elater*, the fire-fly. These three insects are luminous; and *Elater noctilucus* is said to be occasionally used in South America in place of a candle.

Chausey, at Bréhat, or wherever else I may have established the existence of phosphorescence, I have frequently tried to ascertain the cause of those brilliant sparks which shone and disappeared again with the rapidity of lightning. In the water itself I generally found minute Crustaceans, whilst under the stones, and upon the fucus, the luminosity appears to have originated in Annelides and Ophiuridæ.

These results suffice to explain all the circumstances attendant upon the mode of phosphorescence which we are now considering. Natant, or swimming Crustaceans, which lead a wandering life, are never found congregated in sufficient numbers upon one spot to cause the scintillations of individuals to become fused or amalgamated in such a manner as to produce a uniform tint or sheet of light.

The Ophiuridæ and the most minute Annelides, owing to their diminutive proportions, are unable to emit an amount of luminosity sufficient to become united with that of their neighbours; consequently, we find the light which these animals produce, to be exhibited in points, often very closely approximate, but never completely fused together.

In the intertropical seas, or in the Mediterranean, and occasionally even on our own shores of the Atlantic Ocean, animals of larger proportions, or such as live in colonies, are found associated with those just named. These necessarily impart greater *éclat* to the phenomenon, but do not by any means change its general character. In this, as in the ordinary cases that present themselves on our shores, the partial phosphorescence is due to the presence of animals, and those animals are in a living state.

And now let us inquire, whether the same observations are applicable to *general* or *diffused* phosphorescence,—to that phase which imparts to the water, when agitated, the appearance of a fused metal bespangled with scintillations of even greater brilliancy than the glowing surface?

Whoever has merely witnessed the phenomenon would at once unhesitatingly proclaim this to be impossible. He sees, as it were, a sheet of flame spread out before him, whole waves being rendered luminous; and, having steeped his hands in the water, he finds, on withdrawing them, that they too are washed with light! Is it possible, then, to arrive at any other conviction than that this magic influence arises from some substance which is held in solution by the water?

And yet, in every case that I have investigated with the strictest scrutiny, I have found it to be otherwise. The most elaborate researches, as well as the most homely experiments, that I have undertaken, have always satisfied me, beyond a doubt, that even this mode of phosphorescence is due to living

animals; not, in this instance, to *Crustaceans*, but to *Noctilucæ*.

We shall presently revert to the special consideration of these singular forms of life, which play so important a part in one of the most splendid phenomena afforded by Nature. Let us be satisfied, at present, with observing that the Noctilucæ present the shape of little spherules, or rather of diminutive *melons*, whose largest diameter is one-third or half a millimètre.* Their specific gravity is rather less than that of sea-water. Allowed to rest in a liquid which is in a perfectly undisturbed state, they form a layer or coating at the surface, just in the same manner as a number of corks would do; but the least agitation mixes them up with the fluid which before supported them at the surface.

Now, their number is so great that it suffices to produce all the appearances already indicated. Of this the following figures will afford a sufficient proof. I once took some water from a very brilliant wave, and with it filled a tube, one décimètre (about four inches) in height. After it had been permitted to stand a few minutes, the layer formed by the aggregation of the Noctilucæ was one and a half centimètres in thickness; consequently the animalculæ constituted a seventh of the whole mass of fluid. On drawing the water from the *surface* only of a wave just breaking upon the beach (skimming it, as cream is taken from the milk), I filled therewith a large goblet. The total height of the liquid was fifteen centimètres (between five and six inches); that of the layer of Noctilucæ five centimètres, or about one-third of the mixture which I had collected. This is the highest ratio obtained by me; but at False Bay, M. de Tessau found the proportion of animalculæ to be one-half. Without taking into consideration any diversity of species which may exist in those latitudes, this estimate of numbers alone suffices to account for the far greater brilliancy of the phosphorescence there, as compared with the phenomenon with us. It is easy to comprehend how so vast a multitude of luminous corpuscles, disseminated through a body of water, may present an illusory appearance to the eye, just, for example, as the fine molecules of earth, held in suspension in the liquid which they cloud, impart to it a distinct homogeneous colour.

But here again are other experiments that place the question beyond all doubt.†

* A mètre, the French standard measure, is 39·33 inches; a décimètre, centimètre, and millimètre are respectively the 10th, 100th, and 1000th part of a mètre. The diameter of *Noctiluca* is on the average one-fiftieth part of an inch.

† Most of these experiments were first tried by Suriray, a doctor at Havre; they were repeated by Blainville and M. de Tessau; M. Verhæghe added to them, and I myself repeated and diversified them in various ways.

If water, charged with Noctilucæ, and which appears uniformly luminous, be poured into a narrow glass, or, in preference, into a tube seven to eight millimètres in diameter, it will at once be perceived that this water is illuminated only in isolated places. If the luminous points be examined with a pocket lens, the animalculæ are easily distinguishable, and it then becomes apparent that they alone are phosphorescent, whilst the surrounding liquid is perfectly obscure.

After the tube has been allowed to stand for a few minutes, the Noctilucæ rise to the surface and form a luminous layer, below which the water is totally deprived of its phosphorescence.

In order to restore to the liquid its original appearance, it suffices to agitate it slightly, whereby the Noctilucæ are once more disseminated throughout the whole body of water.

In the same manner as the naturalists referred to, I have subjected luminous water to filtration. (A rather fine handkerchief suffices for the experiment.) The Noctilucæ remained upon the linen, to which they imparted a brilliant light; whilst, on the other hand, the filtered liquid presented no signs of phosphorescence, notwithstanding every means employed to promote it. When the Noctilucæ were carefully washed from the filter, and placed in water that was previously dark, they at once imparted to it a phosphorescent appearance. Without entering into further details, I think that these experiments, which may be repeated by persons possessing even the most limited facilities, serve to show that, notwithstanding any appearances to the contrary, the diffused phosphorescence of the ocean is due to the presence of these Noctilucæ.*

But, we may be asked, whether we mean to imply that this is the sole cause of the phosphorescence. By no means. It may be that, as Newland surmises, in some cases, the spawn of certain fishes contributes to its manifestation, or perhaps, in certain exceptional cases, it may be due to some extent to the presence of animal matter, similar to that which is formed on the surface of putrefying fish, and which may become dissolved in the water, as suggested by M. Becquerel, so as to communicate to it a luminous property. Nevertheless, in the presence of facts so clearly established in Europe by several naturalists, and in the latitude of the Cape by M. de Tessau, observations of the

* It follows, as a matter of course, that the Noctilucæ may contribute to the manifestation of *partial* phosphorescence as well, when, as I have often seen them, they are greatly disseminated; and, on the other hand, it has happened that in waves presenting the uniform luminosity which I have called *diffused* phosphorescence, I have met with the more brilliant scintillations produced by Annelides and Crustaceans mixing their light with that of the Noctilucæ.

utmost precision would be requisite to confirm the varying opinions to which we have just referred. It would be necessary to demonstrate, with the aid of the microscope, that the objects perceptible to the eye were *ova*, and not *Noctilucæ* or some similar animalcules; and to prove, by means of the same instrument, the existence of an organic deposit, or, in the latter case, it would have to be shown that the water was still phosphorescent after passing through the filter.

But even if the accuracy of the theories propounded by Newland and M. Becquerel could be proved by observation and experience, in certain special cases, it would still remain an undoubted fact that the phenomenon of which we are treating is essentially due to the presence, in great numbers, of Noctilucæ.

All the researches of the past century, therefore, lead us back to the conclusion arrived at by Rigaut as early as the year 1764.

3. Nature of the Luminosity exhibited by Marine Phosphorescent Animals.

In a paper printed nearly twenty years since, and the first one published by me on the subject,* I remarked that under the designation of phosphorescence there had been grouped together phenomena essentially distinct from one another, and having nothing in common excepting the production of light. In severing *fluorescence*, and studying it as a distinct phenomenon, physicists have to some extent diminished the perplexity arising from the too general use of the former expression (*i.e.* phosphorescence); but the abuse of the term phosphorescence still exists, and nowhere is this so palpable as when it comes to be applied to the property possessed by certain living or dead organisms, of emitting light. Without dwelling upon the consideration of plant-forms, or upon that of animals deprived of vitality, we shall find that the production of light in the latter may be the result of vital actions of very different kinds.

Let us first briefly call to mind the principal views that have been enunciated on the subject. Amongst the numerous theories that have been propounded in order to account for the existence of phosphorescence in living animals, there are some that need only be mentioned to be dismissed.

In this category may be placed those of Beccaria, Mayer, &c., which assimilate it to *fluorescence*,† and who believe that the creatures emit at night the portion of the sun's rays which

* On a new mode of phosphorescence observed in Annelides and Ophiuridæ.—*Annales des Sciences Naturelles*, 1843.

† Fluorescence is, "the diffusion of light and change of colour which

they have absorbed during the day;* that of Brugnatelli, who regards it as the light *ingested with the food* (!), and penetrating to the surface through the vital organs; and even that of Gilbert, who conceives the luminosity of the Noctilucæ more particularly, to be owing to electric sparks drawn from these little creatures by the friction resulting from their passage through the water.

The researches of Spallanzani, Burmeister, and more especially those of Macaire, first cast a true light upon the nature of the phenomenon under consideration. This investigator had employed the insect races as the objects of his researches, and he expressed the opinion that the light emitted by these was the result of a slow combustion comparable to that of phosphorus exposed to the atmosphere. This conclusion has been completely confirmed by the recent researches undertaken by M. Matteucci, weighted, as these are, by the application of all the resources of modern science and the reputation of the author.

The light of the Lympyridæ (glow-worms) and Elateridæ (luminous beetles, commonly known as "fire-flies") is extinguished in a vacuum or in irrespirable gases; it reappears in atmospheric air, and becomes remarkably brilliant in oxygen gas. It is emitted from a peculiar substance possessing the same properties in the living animal as it does after its decease, until completely desiccated; and, lastly, this luminosity is accompanied by a disengagement of carbonic acid. These are all evidences of a true combustion.† But does this explanation, true as regards certain insects, apply also, to those invertebrates whose habitat is the ocean? Dugés and a great number of naturalists have thought so; but it is difficult to understand how such a combustion can proceed in submerged bodies or in fluids, such as those secreted by the Medusæ and Pholades. On dissolving the mucosity produced by the former in milk, Spallanzani rendered the liquid so luminous that he was enabled to read by the light from the glass vessel in which it was contained; and M. Edwards observed that the secretions of some Pholades, which he had placed in alcohol, formed a luminous stratum at the bottom of the glass jar in which it

takes place at the surface of some liquids and solids in consequence of a change in the refrangibility of the different rays."—GRAHAM.

* That such a phenomenon is not only possible, but actually occurs in connection with *inorganic* substances, has been shown by the experiments of M. Niepce de St. Victor, as detailed in our last number, p. 268,—"Actinism."

† The experiments upon which the author of this paper has based his observations on the luminosity of insects are at variance with those of Professor Kœlliker, an account of which appeared in the *Microscopical Journal*, (p. 166) of 1858. M. de Quatrefages has had no opportunity of reading those observations, but requested us to append an abstract of them to his paper, which we have done in a note at the conclusion of this article.—ED.

was contained. Could there have been *combustion* in these two cases? Very accurate and searching experiments, it appears to us, would be requisite before a reply could be given in the affirmative.

Lessou was one of the first, if not the first observer, who considered phosphorescence to be a distinct phenomenon, resulting from physico-chemical action, and bearing a direct relation to some *vital* act; but the expressions employed by him are far too vague to possess any practical value; and, moreover, he is himself not satisfied with his opinions, and insists upon the necessity of special researches on the subject.*

Macartney, Todd, and Coldstream, consider phosphorescence to be due to an imponderable agent, to nervous emanations modified or influenced by the action of certain organs. The last-named observer, judging by the luminous track left by the snail, imagines that phosphorus, or some similarly luminous substance, may enter into the composition of the light-producing organs.†

Meyen and Becquerel, although they admit various kinds of phosphorescence, do not explain the diversity of causes from which the phases of phosphorescence are derived. Ehrenberg, in his elaborate treatise on the subject, appears inclined to attribute all the varieties of phosphorescence emitted by animals to one sole cause. According to his views, it results from vital action, and is produced in a manner somewhat analogous to the electricity of certain fishes. He thinks that the luminous mucus is secreted in a passive state, and is called into action by luminous discharges. (?) So far the views of this eminent savant accord with some of the theories hitherto propounded; but he goes still further, and he has confirmed an important fact, which was revealed to me before I became aware of the labours of Ehrenberg; namely, that under the microscope a light, which was before steady and uniform, is resolved into a vast number of minute scintillations. Ehrenberg, moreover, attributes the production of light, in most cases at least, to the influence of the reproductive organs.

My own observations have revealed to me three different phases of phosphorescence, from which may be inferred actions of a totally distinct character, all resulting ultimately in the production of luminosity.

1. I have witnessed in *Pholades* and *Medusæ*, the secretion

* *Dict. des Sciences Naturelles*, art. "Phosphorescence."

† *Cyclopædia of Anatomy and Physiology*, art. "Animal Luminousness." Macartney and Todd think "that the luminous organs concentrate and modify the nervous influence, so as to form it into light." So that, according to this theory, animal luminousness is an effect solely of vital power; and this view is to a great extent confirmed by the experiments of Kœlliker.—Ed.

of a luminous mucus, which continued to shine after its separation from the animals.

2. On two occasions only I have found *Crustacea*, whose internal substance emitted such a constant and uniform light, that, in the dark, the most minute details of organization were clearly distinguishable. No phosphorescent matter exuded from the body.

3. In the great majority of cases I have seen the light manifest itself in sparks, or scintillations, *along the course of the muscles alone; and only during their contraction.* In this case there was a production of pure light, independent of material secretion.

It is this last mode of phosphorescence, at once the most ordinary and the least to be expected, which has been the special subject of my researches.

My observations were first directed to various species of Annelides, belonging chiefly to the genera Polynoë and Syllis, and to some of the smaller Ophiuridæ, occasionally found in such great numbers under stones, and amongst fucus recently stranded by the tide.*

In common with Dugés, Ehrenberg, and no doubt many other naturalists, I have occasionally seen these Annelides and Radiates emit a light sufficiently powerful to strike an eye-witness, even without his attention being drawn to the phenomenon, and notwithstanding the illumination of a good lamp. The first-named animals more especially presented the appearance (to use an expression of Ehrenberg) of ignited cords of sulphur,—the light appearing to be uniformly distributed over the whole body.

But when they were examined with the aid of a simple lens, this uniform light was found to resolve itself into a series of luminous points placed on either side of the body, and covering the spaces occupied by the little wart-like processes which serve as the locomotive organs of Annelides.

The same appearance was presented in the Ophiuridæ. Now and then the arms (radiating members) appeared to be completely incandescent; but the lens revealed upon each of them a series of luminous specks, alternating with intervals of darkness. The *body* itself is never luminous, and these phenomena are only observable when the animal is in motion. The Annelide must be progressing, or the Ophiura moving its limbs to and fro, before the light becomes perceptible in the surrounding obscurity. As soon as either assumes an attitude of rest, the

* I regret that I did not determine the various species which formed the subjects of my investigations. Absorbed with the study of the phenomenon itself, I was unable to devote to the zoological inquiry the attention which it deserved.

luminosity ceases; motion being resumed, light also reappears.

To me these observations, which are very easy of repetition, served as a starting-point for further inquiries. Phosphorescence being so palpably associated with locomotion, it was only natural to seek the seat of the former in the muscular system. This I long essayed in vain. The employment of the microscope became necessary, and the difficulty lay in these circumstances. It was needful in the first place to adjust the instrument, so that the luminosity should be exhibited exactly at the focus; and, secondly, that the light produced should be sufficiently powerful to be perceptible, notwithstanding the subdued light requisite to reveal the parts placed under the object-lens. After much groping, and many fruitless attempts, I succeeded in surmounting these difficulties; and even whilst I write, it is a source of lively pleasure to me to recall the sense of astonishment with which I witnessed for the first time in a little Polynoë (no doubt as brilliant an example as that which Ehrenberg has designated "fulgurans"), the motor muscles of the bristles suddenly illumined before my eyes, under a magnifying power of 100 diameters.

The muscles alone emitted light, the other portions of the foot remaining perfectly obscure.

But now another phenomenon presented itself quite unexpectedly. What the simple lens had done in regard to the entire body, the microscope performed for the foot. These muscles again were not uniformly luminous throughout their entire length; but there appeared disseminated over them a vast number of exceedingly minute, but at the same time remarkably brilliant points, which appeared and vanished again with the rapidity of lightning.

The outline which they presented consisted not of an uninterrupted track of light, but of a line formed by a succession of scintillations.* Lastly, I discovered that these scintillations (and consequently the "phosphorescence" which was visible to the eye) were only emitted during the contraction of the muscles. An examination of the Syllidæ and Ophiuridæ revealed precisely the same phenomena as I had observed in Polynoë, and I therefore regard them as a confirmation of my views on this interesting subject. How is it possible that a luminosity manifested in the very recesses of the living organ-

* The author compares the effect visible in this case to that exhibited by what he terms the "magic tablet" of electricians. It is a tablet of glass on which representations are made with spangles of tin-foil, and when the discharge takes place, the figure appears in sparks of light, not in a continued luminous outline. A similar effect is produced in "Barker's spotted tube."—See Jabez Hogg's "Elements of Natural Philosophy," p. 450.

ism, in those tissues which of all others maintain the greatest amount of activity, and during their most energetic action, could bear any relation to the physico-chemical forces which we bring into play in our laboratories? How indeed can such a phenomenon be regarded otherwise than as the result of a vital act?

This was my view of the case; and here I found myself at one with Ehrenberg; but I had gone farther than he had done, for I had satisfied myself that the seat of the phenomenon was in the muscular tissue, and was closely related to its contraction.

These two entirely novel and unexpected results, however, needed verification by experiments on other animals, and I eagerly availed myself of the opportunity presented by the Noctilucæ of the port of Boulogne to subject my opinions to a fresh test. The very important part which they play in "general phosphorescence," that is to say, in the phenomenon on its grandest scale, gave a special interest and importance to their study; whilst the infinitude of these animalculæ, and even their minute proportions, afford to the experimentalist greater facilities than any that I had previously possessed.

In the first place, however, it was necessary to become intimately acquainted with the organization of the Noctilucæ themselves; and the results of this twofold study now remain to be described.

4. The Noctilucæ and their Phosphorescence.

The Noctilucæ (*Noctiluca*, Surriray; *Mammaria*, Ehrenberg) are, as we have already stated, microscopical animalculæ bearing a pretty general resemblance to little melons deeply indented at one end.

Near this depression there is fixed an appendage, which the animalcule moves slowly to and fro, swaying it from right to left (see Figs. 1 and 2, A, B.). The body is so completely transparent as to admit of its structure being studied in its minutest details. It is inclosed by two hyaline membranes, representing the *dermis* and *epidermis*.* Near the appendage these membranes present a minute orifice, which serves as the outlet from a little mass of pellucid, homogeneous, and finely-granulated substance, which is prolonged into the internal part of the body. From this mass, which forms as it were a centre, there radiate in every direction a number of rhizopodic † extensions, which become more and more ramified as they proceed, and of which the ultimate indefinitely multiplied ramifications

* The names given by physiologists to two coats of the skin.

† The reader will recollect that we had to employ this expression in treating of Amœba, &c. (of the Rhizopoda, in fact), in the articles on the "Lowest forms of Life," Nos. I. & II. of this Journal.

spread themselves over the whole inner surface of the animal (Fig. 1). An absolutely limpid and transparent fluid fills up the interstices, and this it is which imparts, or rather maintains, for the animalcule its general rounded form. Should this fluid accidentally make its escape through the minutest aperture, the animalcule immediately loses its shape and sinks to the bottom. The reader may form some conception of the general appearance exhibited by the remarkable internal structure of Noctiluca by a reference to Figs. 1 and 3; but in order to understand the strange spectacle which it presents in the living animal, it is absolutely necessary to watch the latter with persevering attention. It then becomes evident that neither the prolongations, nor yet the central mass from which they radiate, have any fixity of shape; that they are in continual motion, and susceptible of constant modifications. The larger branches are seen under the microscope to become attenuated, in consequence of the substance of which they are composed passing into the neighbouring ones; whilst the minute ramifications assume larger proportions, inasmuch as they borrow the materials from others in their vicinity. Here and there *vacuoles* make their appearance, and increase in dimensions, whilst others previously existing diminish in proportions, and are finally lost to view.

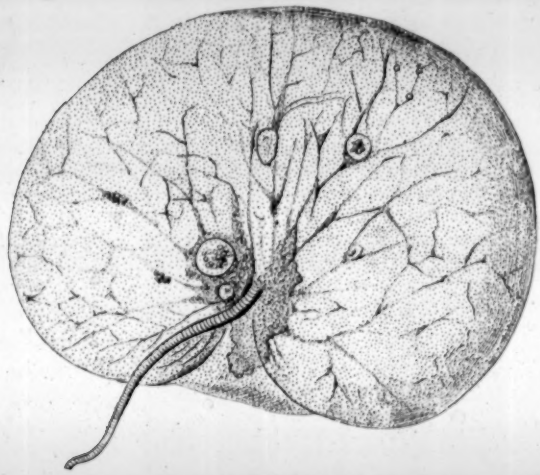
It will also be observed, that some of these vacuoles are formed near the orifice; that they inclose or surround * granules of green substance, or the powder of carmine or indigo, which may have been mixed with the water; then, detaching themselves by degrees from the central mass, glide along one of its chief prolongations and fulfil the functions of a temporary stomach; for they rotate with this alimentary pillule round the whole body, and finally return to the point from whence they originally departed.† In short, the little mass and its extensions are found to consist entirely of *sarcode*, that primary animal substance so carefully studied by the late lamented Dujardin, in the external prolongations Gromia, Miliola, and so many other of the marine and fluviatile Rhizopoda.‡ And

* Or, as the author more appropriately designates it, "*englober*," a word for which we have no equivalent in English.

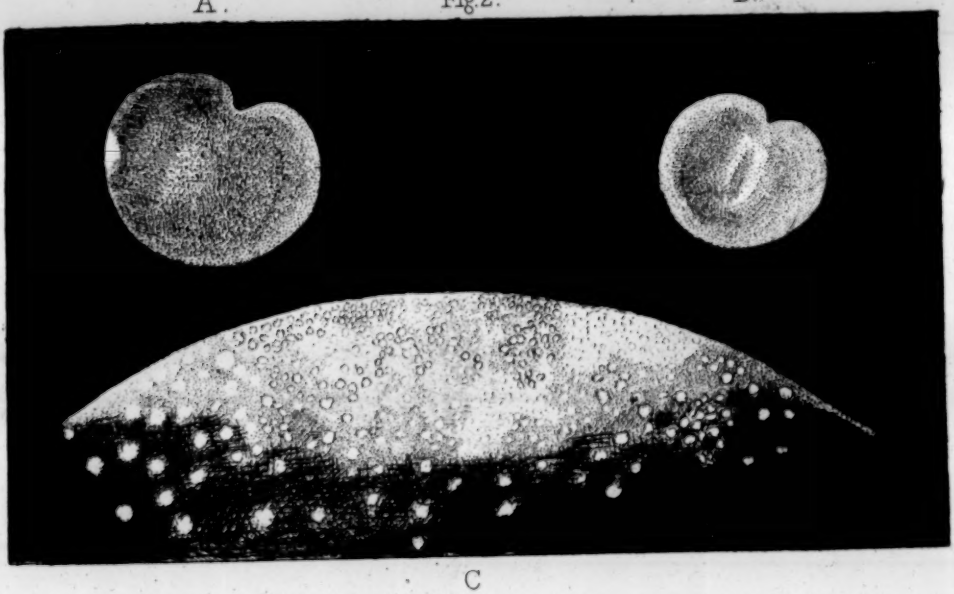
† In the articles just referred to ("Lowest Forms of Life") we had occasion to describe these "vacuoles" as temporary receptacles for the nourishing fluid of the body; indeed the reader who has paid any attention to the subject will no doubt already have come to the conclusion that these Noctilucæ are but one degree removed from the lowly organisms described elsewhere.

‡ The Rhizopoda of Dujardin, which include the Foraminifera of D'Orbigny, are regarded as perfect animals, and form a distinct branch in the classifications of zoologists; but for my part I am convinced that they are only larval forms, and that their later stages remain to be discovered.—A. DE Q. Such of our readers as desire to study the Foraminifera, will have an excellent opportunity of doing so on the appearance of Dr. Carpenter's work, to be published shortly by the Ray Society.

Fig 1.

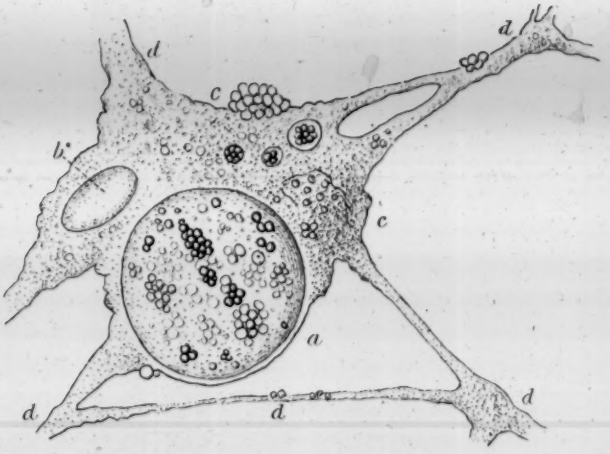


A. Fig 2. B.



C

Fig 3.



T.West sc.

W.West imp.

Noctiluca miliaris & its structure.

now we must call to mind the fact, that amongst the most characteristic properties of "sarcode," we find what may be designated an *indefinite contractility*. Such is the entire constitution of the inner substance of the Noctilucæ, in which no other distinct organization is visible; and we shall now proceed to inquire into the nature of the "phosphorescence" produced by animalculæ so remarkable for the simplicity of their structure.

First, it is easy to recognize beyond all doubt, that the emission of light takes place independently of all contact with the atmosphere; and that it is not influenced by the nature of the gas with which they are brought into relation, provided it does not cause sudden death.

The first statement may be easily verified by collecting a colony of Noctilucæ in a glass tube, so that they form a layer of 10 to 12 centimètres (about 4 inches) in thickness. It will then be found that the column is equally luminous throughout its whole extent, notwithstanding that the uppermost portion rises almost above the surface, whilst the remainder is deeply submerged. If we go so far as to place the Noctilucæ in as perfect a vacuum as can be obtained, we find that, far from losing their luminous property, they shine with a continued brilliancy till life becomes extinct; but then the attempt to excite their luminosity, even by the admission of oxygen gas in place of atmospheric air, is quite futile: it has disappeared for ever. Finally, if Noctilucæ be placed in inverted tubes, and if we introduce severally into these tubes, atmospheric air, oxygen, hydrogen, nitrogen, and carbonic acid gas, the results will be found to be alike in each, neither description of gas affecting the luminosity in a manner different from the rest.

These experiments suffice to prove that the light emitted by Noctilucæ is certainly not the result of combustion; and the following serve to show that it is independent of any external secretion.

We have already stated that luminous water passed through linen is quite dark after filtration, leaving the luminous animalculæ upon the filtering material.

The same result follows if, instead of water, we employ milk—a fluid which becomes so readily charged with the luminous mucus of the Medusæ.

Again, if Noctilucæ be placed in ether, it remains perfectly obscure; the animalculæ forming a luminous sediment at the bottom of the tube. Again, if the hands or any object be rubbed with the Noctilucæ remaining upon a filter, it sometimes happens that luminous traces are the result. These one might be led to attribute to some luminous secretion, either internal or external; but a nearer examination with the lens leaves no doubt that these traces are due to fragments which

retain their luminosity so long as they continue to possess organic contractility.*

In short, it is to contraction, and to that alone, to which I consider the production of light attributable. This conclusion, however, was only arrived at after I had compared the results of two series of experiments—the one tried in the daytime, the other at night: these experiments being diversified, but each series in strict correspondence with the other.† Thus, I tested the action of heat, compression, electricity, and of ten chemical substances, alkaline, acid, and neutral,—the general result being that any agent whatsoever capable of causing the sarcodic substance of the Noctilucæ to contract, was efficacious in precisely the same degree and at the same time in producing phosphorescence. An isolated shock caused, during the daytime, a violent but momentary contraction; at night it gave rise to a bright but transient exhibition of light. Under the influence of continued, or of too violent irritation, the whole substance of the body is seen, in the daytime, to contract to such an extent as to become liberated from the external envelope, gradually to sink down, as it were, and become disorganized or lose its vital properties. At night, the same operation leads to a continued phosphorescence apparently pervading the whole animal, and of which the steady and permanent brilliancy always denotes approaching dissolution. Thus, contraction and phosphorescence are invariably met side by side, and proceeding, as it were, step by step.‡

The contraction may be either partial or general, and it may manifest itself in different places at the same time; so also with the luminosity. This is easily observable with the aid of a pocket lens. It is only necessary to pour water containing Noctilucæ into a tube and shake it a few times, when the little luminous spheres at once become clearly distinguishable, and their movements may be readily followed.

They will be found to present the appearance which I have sought to depict in fig. 2, A, B, and occasionally the same animalcule is seen to become illuminated at two points in succession. If the tube be repeatedly shaken, or (what is a still more

* I have ascertained the same thing to be the case in the locomotive organs of Annelides.

† By this, I mean that I repeated at night the experiments tried during the daytime, in such a manner as to be able to compare the results. Thus, for example, whatever produced contraction during the daytime, imparted luminosity at night.

‡ These experiments are not easy. The use of the compressor is requisite in their performance, and the operator must be an adept in its employment. It requires two persons to conduct the experiments by night. M. Bouchard was kind enough to co-operate with me in all these researches.

efficacious agency) if a little alcohol be added, the effect becomes very marked. The light of the whole is perceptibly increased, and those animalculæ whose entire substance shines with a steady white light, multiply considerably in numbers.

This result may be exhibited in a most pleasing manner as follows:—a long tube must be filled with water well charged with Noctilucæ, and a drop or two of sulphuric acid subsequently poured gently into the tube. In its descent this will acidulate the water, and will be found to operate as one of the most active irritants that can be applied to the animalculæ, of which it rapidly disorganizes the substance. As, therefore, this formidable drop descends, it appears to ignite the Noctilucæ in its passage, and thus its downward course may readily be traced.

Here, again, is a still more beautiful experiment producing similar effects.

If the lower extremity of a tube, replenished as above, be plunged into water raised almost to the boiling point, at the moment of its immersion not the least light is visible.

Soon, however, some scintillations are apparent at the bottom of the tube, and as the liquid becomes heated, and the warm currents rise from below upwards, the luminous animalculæ multiply in numbers. In a few moments they are all luminous, and the tube then presents the appearance of a fiery rod. This brilliancy does not, however, last long: the little illuminated balloons are extinguished one after another, and do not recover their luminous properties even if transferred to cold water. When I tried the experiment, a temperature of 39° * had killed them all.

But there are no observations connected with the Noctilucæ that will compare in beauty and interest with those which may be made with the assistance of the microscope.

In proportion as the magnifying power of the instrument is increased, we see reproduced in each animalcule the effect that we noticed on approaching the luminous waves of the sea-beach.

Examined with a power of 20 to 30 diameters, the illuminated portions of the body of Noctilucæ present a uniformly bright aspect. With 60 diameters a number of small but brilliant scintillations become visible, detaching themselves, as it were, from parts of what appears to be a pale luminous background; and these scintillations come and go with the rapidity of lightning. An enlargement of 150 diameters, however, reveals the true character of the phenomenon. It then becomes obvious that the light emitted from the whole body, or any of its parts, is composed of a vast number of instantaneous scintil-

* 39° Reaumer equal to a little less than 120° Fahrenheit.

lations, closely approximating to one another at the centre of the "phosphorescent" portions, but disseminated and clearly distinguishable at the edges. Occasionally there may be seen isolated sparks at the extreme limit of the luminous part, or even beyond it (fig. 3). In employing very fresh and vigorous examples of Noctilucæ, I have been enabled myself to inspect and to exhibit this phenomenon to M. Bouchard-Chantereaux under a magnifying lens of 240 diameters.

Thus we find in the Noctilucæ the same phenomena which we observed in the Annelides and Ophiuridæ. In neither case does the spark which presents itself consist of an unbroken body of light, but it represents, so to speak, the sum total of an infinite number of evanescent scintillations. Each luminous manifestation is a nebula, so to speak, resolvable, with a sufficiently high magnifying power, into a cluster, just as we find it to be the case in a celestial nebula. But in this instance there are no "fixed stars;" for even when the luminous point remains apparent to the unaided vision for a few moments, and the microscope is brought into play, this is not only decomposed in space, but is also resolved in *time*, the component scintillations being instantaneous and evanescent!

It is quite obvious from the facts thus revealed, that the luminosity of Noctilucæ is a phenomenon very different in character from that of phosphorus exposed to the air. No one would for a moment pretend to say that scintillations such as those exhibited under the microscope could be the result of a *slow* combustion; and an *active* combustion (which is always accompanied by great heat) could not proceed in the very heart of the living tissues. Indeed, careful experiments have satisfied me that no elevation of temperature takes place even where the luminosity of the animalculæ is most brilliant; there has been no apparent influence upon the most sensitive thermometer when plunged into a mass of these forms all brightly luminous, presenting, indeed, the maximum of phosphorescence.

In the electrical fishes, we know that there is a special apparatus for bringing into play the physical agent, *electricity;* in the Lampyridæ a particular organ secretes the phosphorescent matter: Ehrenberg has described similar luminous organs in Photocharis and Thaumantias, and Meyer in Pyrosoma.

Nothing of the kind, however, exists in the Ophiuridæ or Annelides which I have carefully investigated; nor is it the case, as we have seen, in the Noctilucæ. Here the living organism itself, and what may be termed *par excellence* the vital tissue, namely, the muscular, produces the luminosity solely in virtue of its vital function, namely, in that of contraction; and the light emitted appears to be perfectly pure and independent of any other product.

Whether or not the reader will be able to share with me the impressions left by those remarkable appearances which I have witnessed and sought to describe, I cannot say, but it appears to me that no physiologist can fail to regard with satisfaction the circumstance that *life* performs the chief part in one of the most magnificent phenomena that the eye of man can contemplate, and which has hitherto been usually attributed to the physico-chemical forces.

LIST OF PHOSPHORESCENT ANIMALS REFERRED TO IN THE TEXT.

No. 1, is from "Todd's Cyclopædia"; No. 2, from Verhœghe's article on "Phosphorescence of the Sea on the Coast in the Neighbourhood of Ostend."

I.

INSECTA.

Lampyris: L. noctiluca, L. splendidula, L. italica, L. ignita, L. phosphorea, L. nitidula, L. lucida, L. hemiptera, L. japonica.

Elater: E. noctilucus, E. ignitus, E. phosphoreus, E. lampadion, E. retrospiciens, E. lucidulus, E. lucernula, E. speculator, E. janus, E. pyrophanus, E. luminosus, E. lucens, E. extinctus, E. cucujus, E. lucifer.

Bupestris ocellata.

Chiroscelis bifenestrata.

Scarabæus phosphoricus.

Pausus sphærocerus.

Fulgora: F. laternaria, F. serrata, F. pyrrhorhyncus, F. candellaria.

Pyralis minor.

Acheta gryllotalpa ?

II.

MYRIAPODA.

Scolopendra electrica, S. phosphorea, S. morsitans.

Julus ——— ?

CRUSTACEA.

Cancer fulgens, &c.

Carcinum opalinum.

Erythrocephalus macrophthalmus.

Scyllarus (species doubtful).

Gammarus pulex.

Cyclops brevicornis.

Oniscus fulgens.

ANNELIDA.

Nereis: N. phosphorans, N. noctiluca, N. cirrhigera, N. mucronata.

Syllis fulgurans.

Photocharis cirrhigera.

Polynoë fulgurans.

Chœtopterus pergamentaceus.

Lumbricus phosphoreus.

Planaria retusa.

MOLLUSCA.

Helix noctiluca.

Pholas dactylus.

Pyrosoma atlanticum, P. giganteum.

Phallusia intestinalis.

Salpa zonaria, S. tilesii.

ECHINODERMATA.

Asterias ——— ?
Ophiura telactes, O. phosphorea.

ACALEPHÆ (or Cœlenterata).

Pelagia phosphorea, P. noctiluca.
Oceania Blumenbachii, O. pileata, O. hemispherica (thaumantius), O. lenticula, O. microscopica, O. scintillans.
Beroe fulgens, B. rufescens.
Cydippe pileus.
Mnemia Norwegica.

POLYPI (or Cœlenterata).

Pennatula phosphorea, P. grisea, P. rubra, P. argentia.
Veretillum ——— ?
Gorgonia ——— ?
Sertularia ——— ?
Alcyonia ——— ?

INFUSORIA.

Ceratium tripos, C. fusus.
Peridineum Michælis, P. acuminatum, P. furca.
Prorocentrum micans.
Stentor ——— ?
Synchœta Baltica.
Noctiluca (Mammaria) miliaris.

TRANSLATOR'S NOTES.

NOTE 1.—The following is a short abstract of Professor Kœlliker's "Observations on the Nature of the *Luminous Organs of the Glow-worm* (*Lampyris*)," (with comments on their bearings in regard to the subject under consideration,) which were translated by the writer, and published *in extenso* in the "Microscopical Journal" for 1858, p. 166.

Lampyris possesses, upon certain rings of its body, a double series of flattened luminous plates, appearing white to the naked eye, and presenting the greatest amount of luminosity when viewed from above. These organs consist of an "investing membrane," inclosing a "parenchyma" (internal substance) "composed of *cells, tracheæ*" (*i.e.* respiratory tubes), "and *nerves*." The cells which constitute the internal substance of these organs are of two kinds, called by Kœlliker "pale" and "white;" their structure is minutely described by him, also the tracheæ and nerves, of which he has carefully followed the ramifications.

We may at once here state, that if Kœlliker's observations in this respect be accurate (and he is a careful and reliable observer), the luminosity cannot be the result of *combustion*, any more than in Noctiluca, for it proceeds in the very depths of the vital organism, amongst delicate respiratory tubes, "forming the most abundant and elegant ramifications among the *pale* cells." "Now" (the observer continues), "*the proper luminous substance* does not consist in the *white* cells," but in the "*pale*" ones, "as may be readily proved by direct observation of the luminous organs under the microscope by night, when the light of the lamp is shut off."

The contents of these cells, he says, "are albuminous;" they do not contain "phosphorus," as was stated by Leydig, another observer, but a uric acid salt, probably urate of ammonia. This latter discovery Kœlliker put to the strictest chemical tests, always with corresponding results; and, on the other hand, he satisfied himself, by the employment of other tests, that no phosphorus was present.

Kœlliker believes the luminosity of the glow-worm to be dependent on the will of the animal, but not (as De Quatrefages regards that of Noctiluca, the marine Annelides, &c.) to be at all influenced by movements. He says, "Even in the night-time, individuals may be noticed performing the most active movements, and yet showing no luminosity whatever."

He tried the effects of various irritants—mechanical, electrical, thermal, and chemical; indeed, from the account which he gives of his various experiments, he seems to have treated the glow-worm much in the same manner as De Quatrefages tested the luminosity of his little Protozoans, and his conclusions are "that the luminous organs are a *nervous apparatus* whose nearest analogues may be sought in the electrical organs" (of fishes, such as the Electrical Eel, *Gymnotus*, &c.)

"All excitants of the nerves excite the luminosity, and the agents which annihilate the nervous functions act injuriously in this case also. My experiments wholly subvert the theory hitherto current, which assumes the existence of a luminous material secreted and deposited in the organs, a sort of phosphorus, which on the addition of oxygen through the respiratory movements becomes oxydized, and consequently luminous."

After showing that the tests applied by him prove that no such substance can be present, he concludes by stating that "the light is produced under the influence of the nervous system, and in all cases is maintained only for such a period, whether long or short, as the nerves, stimulated by the will or otherwise, act upon the organs."

The reader will perceive, therefore, that although this account of the luminous organs in insects (so far at least as the glow-worm is concerned) is at variance with the theory adopted by our able contributor regarding that class of animals, yet it is confirmatory of his conclusions that phosphorescence, or, more correctly speaking, "animal luminousness," is the result of vital and not of physical action. And, moreover, the investigations of these two inquirers may suggest to some of our readers, as they have done to us, the probability that the phenomenon observed by the one in the Annelides and in Noctiluca, and by the other in Lampyris, may be of a like nature. That is to say, it is quite within the range of probability that both may result from, or be influenced by nervous action, and that the "scintillations" so beautifully described by M. Quatrefages may have taken their course along the *motor nerves*.

This is an inquiry of great importance to physiologists, for if it can be established that luminosity is invariably related to nervous action (when there is no perceptible secretion of phosphorescent matter), it will necessarily follow that Noctiluca, and probably all the lowest forms of animal life in which no nervous system has yet been traced, possess at least the rudiments of one; and this is rendered still more probable in consequence of the diffused or pervading character of the luminosity in the lowest forms, as in Noctiluca

when compared with the Annelides: for in the former it is natural that where no other organs are as yet differentiated, that is, transformed or developed from what may be termed the crude material (sarcode), the nerve substance should also be diffused and without definite form.

We recommend this interesting inquiry to the attention of our readers.

NOTE II.—To such of our readers as are desirous of entering more fully into this subject, we recommend the careful perusal, not only of the foregoing observations by Kœlliker, but of Mr. Brightwell's Paper on the "Subdivision of Noctiluca" (*Micros. Jour.*, 1857, p. 185), beautifully illustrated by Tuffen West.

DESCRIPTION OF PLATE.

Fig 1. Noctiluca, as commonly observed; enlarged and seen by transparent illumination. *a.* Motile appendage; *b.* mass of granular substance closing the orifice of the general cavity, and from which the sarcodic extensions are seen to radiate.

Fig. 2. Enlarged Noctiluca seen in darkness. *a.* Phosphorescent in parts; *b.* phosphorescent throughout its substance; *c.* phosphorescent portion of a Noctiluca, seen with an enlargement of 240 diameters.

Fig. 3. Portion of the sarcodic substance of Noctiluca exhibited transparently, and enlarged 150 diameters. *a.* Large vacuole inclosing particles of green matter, and of carmine, swallowed by the animalcule; *b.* smaller vacuoles containing liquid only; *c.* parts of sarcode containing vacuoles that have collapsed—this portion of the body is amœba-like (constantly changing its form); *d, d, d, d,* extensions of the sarcodic mass, also variable in their character.

THE SUN AND SOLAR PHENOMENA.*

BY JAMES BREEN, F.R.A.S.

DURING the past year the Sun has been in an extraordinary state of perturbation, and it need scarcely be added that those observers who take an interest in solar phenomena have been in a corresponding degree of excitement. The surface of the great central luminary has broken out into an eruption of dark spots, and the telescope can scarcely be pointed towards it for a moment without our perceiving several clusters of those irregular and strange-looking blotches which dim its otherwise glowing orb. No alarm, however, is created among astronomers by the unusual number of those specks; their return in such plenty is purely periodical, and it is not in the least expected that they will go on increasing indefinitely, but rather that they will gradually diminish in dimensions as well as in numbers during the next five years; again, however, at the lapse of this interval, to recommence the cycle of their wonted appearance in more considerable groups. It is not in the least feared that the sun's light will be obscured or its heat lessened by those motes which are commingled with its beams; it will still germinate, nourish, and ripen fruit and flower,—still produce rain and whirlwind,—still purify and revivify our atmosphere by lighting,—still go on effecting those mighty changes on land and water which render our globe habitable. Lagrange has proved and foretold the invariability of the seasons on the earth. Equally satisfied are observers that, notwithstanding the continual changes on its surface, they shall see for ages yet to come the sun's light reflected from planet and satellite during the night in the same degree as they see its fiery glow from hill and dale during the day. Its light, passing through showers of ice-crystals in the distant summer atmosphere, will continue to produce those white circles (or halos, as they are termed) visible at times round its luminous disc; by means of the sprinkled water-drops it will still paint in colours of unequalled splendour the brilliant rainbow, which, like hope, may rest upon the darkest and most sombre cloud in the heavens. The rosy fingers of Morn shall still open the

* With an account of the Eclipse of the Sun in 1860, as seen by the author in Spain.

curtains of the East, and the crimson sunset still make its appearance, whilst both will preserve their usual tints as if this violent agitation proceeded not on the surface of the sun.

The *statistics* of the sun's weight and distance and size are so well known, that it may here appear out of place to repeat those data. As an illustration, however, of its overwhelming size, we may state, that if all the planets of the system were rolled up into one mighty ball, still, however, this would appear a mere pigmy in comparison with the vast globe of the sun, which would fill a space some six hundred times larger than this great collection of matter. If the heavy rocks and minerals of the interior planets were macadamized and mixed up with the clay and sand and water of the exterior ones, it would be found that, light as are the materials of which the sun is composed, its mass would outweigh not less than 738 of such fictitious globes piled up in the opposite scale. It would take more than 350,000 globes like our earth to weigh it down. The ocean of fire which surrounds it is more than 20,000 times greater than the surface of the Pacific Ocean, and more than 12,000 times greater than the area of the whole earth. The domain over which it presides would be considered marvellously great were we ignorant of the vastness of the starry spaces, or of the infinite number and distances of those luminous objects of which the sun in all its glory represents but a single unit. In comparison with those spaces, which a ray of light takes years to traverse, how small is our distance of ninety-five millions of miles from the central body,—how small even the distance of the exterior planet Neptune, when, representing the vast dimensions of the sun by a ball only two feet in diameter, and preserving the same scale throughout, we should have Neptune about the size of a plum at a distance of a mile and a quarter from the body round which it revolves!

In the telescopic aspects of the other planets we perceive many striking similarities with the economy of our own globe: mountains on Mercury and Venus, snows on Mars, trade-winds on Jupiter and Saturn; the alternations of day and night, and many signs of the existence of atmosphere, on all the planets. They are illumined by the same light, warmed by the same heat, and pursue their courses around the same fixed star as the earth. But another world opens when the attention is directed towards the sun. The blue and limpid atmosphere of the earth bears no analogy with the dense and fiery crust which surrounds the solar orb. Immense openings, more like the bursting forth of a volcano, where the lava is thrown aside in torrents and the whole surface is a sea of liquid and seething fire, have no similarity with the feathery clouds or drifting masses of light vapour which are seen in the atmosphere of

the other bodies of the system. Imagine a degree of heat some three hundred thousand times greater than that which exists on the earth, and which would turn our purest metals into fumes. No end of wild conjectures or grand conceptions can be made in connection with the scenery of this new world.

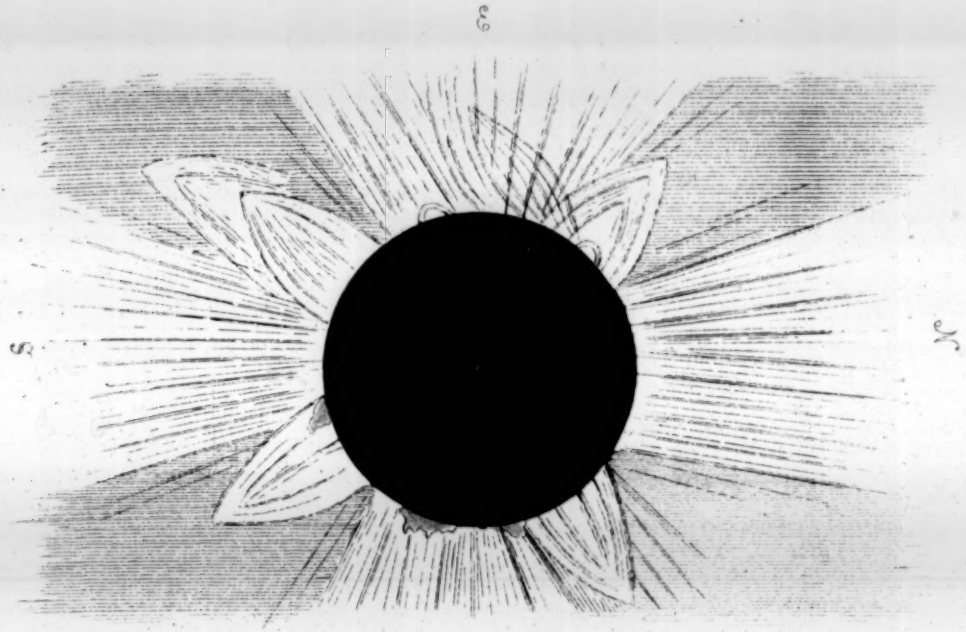
> What wonder, then, if fields and regions here
> Breathe forth elixir pure, and rivers run
> Potable gold, when with one virtuous touch
> Th' arch-chemic sun, from us so far remote,
> Produces, with terrestrial humour mixed,
> Here in the dark so many precious things
> Of colours glorious and effects so rare.

It must not be forgotten, however, that the principal error of those who start theories on the light and heat of the sun,—who would reduce those elements to material fuel and agency,—has been in their supposition that the sun and planets—the donor and the recipients—are bodies of a similar nature, and that the same conditions are general throughout the system, whether it be star or planet, satellite or comet.

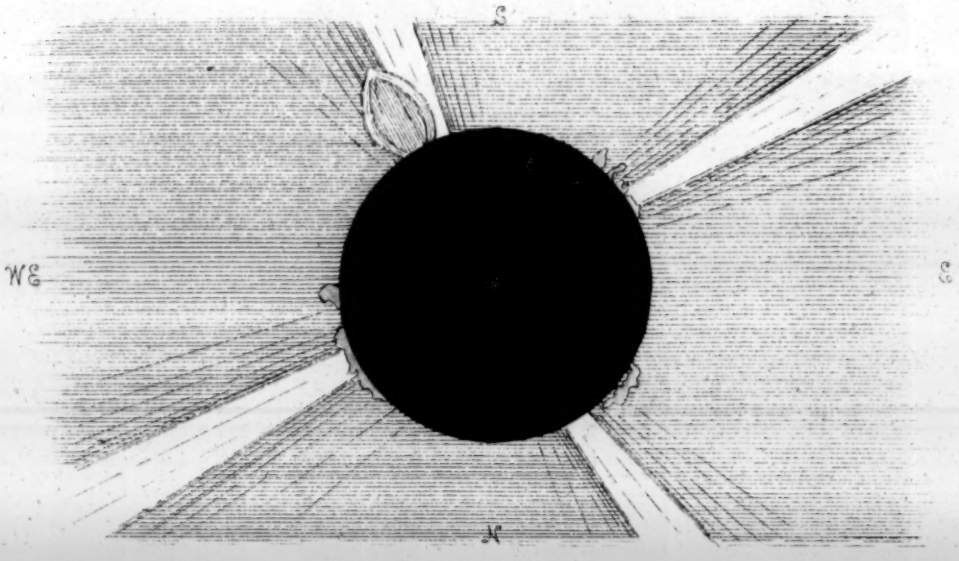
Those who have looked at the sun with a telescope of even moderate power, have of course observed the dark spots on its disc. They have seen them of every conceivable size and form, and it very seldom happens that they have any appearance of regularity further than that they are commonly approximately circular. These spots are surrounded by a lighter shade, which is mostly of the same form as the central speck, and which seems like a fringe of less-dense material, parting abruptly from the more obscure kernel which it incloses. This intermediate shade does not mix with the densely black nucleus, at the same time it is distinctly separate from the illuminated surface of the sun. This is most strictly true in every instance: the *nucleus* or spot proper is of one tint, and that a very intense black; the *penumbra*, or fringe, of an equally constant though much milder degree of shade—a sort of half-mourning; whilst the brilliant lustre of the solar surface makes a third tint. There are thus three distinct and sharply-defined grades, and these facts must be strictly borne in mind by all those who would endeavour to explain the physical constitution of the sun. Sir W. Herschel accounted for it in this manner: The outer luminous surface which it blinds us to look at he considered is composed of a fiery and cloudy matter supported by a transparent medium similar to our atmosphere. When the bright envelope, either from volcanic disturbance or other agitation within, or from currents from without, is broken, we perceive the upper portion of the inner atmosphere illuminated by the light which it receives from above, and at the same

time we see through the opening the dark body of the sun itself. There can be no doubt but that the spots are pits or holes gradually shelving down into the sun's body. This can be immediately seen by following any well-defined and round spot as it is carried across the disc by the sun's rotation on its axis (in 25¼ days); but the above explanation is, after all, only a conjecture, though the most plausible which has been broached on the subject. Secchi has measured the depth of those wells, and found them to be about one-third of the diameter of the earth, or about 2,600 miles in profundity. After an attentive study of the spots, Sir John Herschel says:—"The idea conveyed is more that of the successive withdrawal of veils—the partial removal of definite films—than the melting away of a mist, or the mutual dilution of gaseous media. Films of immiscible liquids having a certain cohesion, floating on a dark or transparent ocean and liable to temporary removal by winds, would rather seem suggested by the general tenor of the appearances; though they are far from being wholly explicable by this conception, at least if any considerable degree of transparency be allowed to the luminous matter."

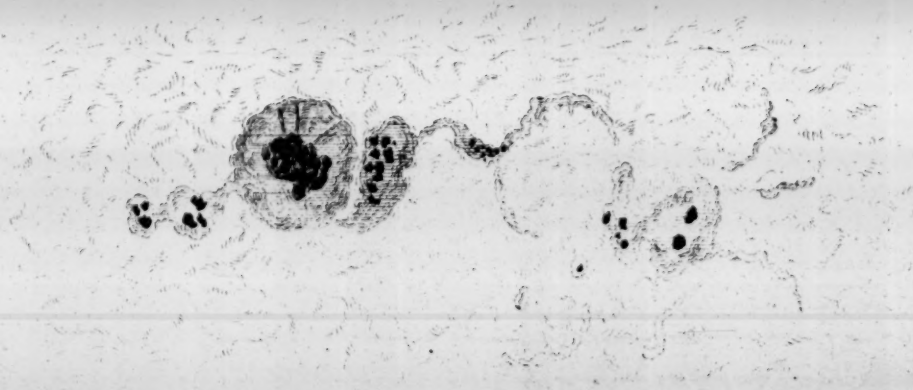
But having gazed, to his heart's content, at the nuclei and penumbræ, the observer will, no doubt, scrutinize the remaining portion of the sun—the luminous surface, with much interest. Here, again, new variations of light and shade meet his gaze. Let him first take the whole surface of the sun into view; he will at once observe that at the edges the light becomes gradually dimmer, and that the contrast between the centre and the margins is very great in this respect. By placing a sheet of paper (instead of the eye) a short distance from the eye-piece of the telescope, when an image of the whole surface of the sun is obtained, this difference of luminosity is immediately perceived. It is argued from this, that there is an atmosphere extending considerably beyond the apparent surface of the sun, imperfectly transparent, which prevents the solar light from coming to us with the same intensity whilst traversing great thicknesses and different strata of air, with that where it passes in a simple and direct line, as through our zenith, or the centre of the sun. With this luminous surface of the sun no other light can compete. The most brilliant artificial flame appears as a patch of smoke on the disc of the orb of day. It has been found that the brilliant light given forth by the ball of ignited quicklime (invented by Lieut. Drummond) is only equal the one 146th part of the light at the surface of the sun. M. Foucault has, however, by passing the current of the voltaic pile through certain metals, found in the electric light produced, when decomposed by the prism, brilliant bands superior in brightness to the corresponding bands furnished



ECLIPSE AT PARANAGUÁ SEP 7 1858.



ECLIPSE AT CASTELLAN DE LA PLANA. JULY 18. 1860



SPOTS & FACULÆ ON SUN FEB 9 1862

by the rays of the sun. Scrutinizing this luminous surface with high powers, we further perceive that the light is not uniform, but that it is covered with bright points, giving it a porous appearance, which has been aptly compared to the skin of an orange. At the last meeting of the Royal Astronomical Society, a photograph, taken by Mr. De la Rue, was exhibited, which represented this rough surface with the greatest accuracy, much more perfectly than could be possible in any engraving. Those bright specks very frequently attain to much greater dimensions, and are often visible, particularly at the margins of the sun, under the form of long serpentine and bright blisters, much more lustrous than the ordinary surface of the sun, however bright that may be. All these are as changeable as the spots. These bright streaks (or *faculæ*) are proved to be considerably elevated above the surface of the sun. Thus we find that if the sun exercises great influence on the surface of our globe, it must be acknowledged that its own atmosphere is equally disturbed, though the causes of those changes are less explicable. The spots and bright streaks are continually appearing and disappearing, varying in form and size, breaking up or collapsing every hour. Sometimes they take the form of a whirlpool, and even seem to have a sort of spiral or rotatory motion. Any observer, with a fair telescope, is able to perceive all those phenomena; and in no other subject of practical astronomy is the aid of the amateur so useful in determining the positions and annual number of the spots. To another object constantly accompanying the sun, but best seen in our latitudes during the spring evenings or autumn mornings, the services of the amateur are very valuable. We allude to the cone of faint light seen after sunset or before sunrise along the ecliptic, and which has hence obtained the cognomen of the zodiacal light. Humboldt has searched in vain for any allusion to it previous to that of Childrey, in 1661; but an admirer of Shakspeare might, perhaps, think that this phenomenon was described in the lines,—

> "Yon light is not daylight, I know it, I:
> *It is some meteor that the sun exhales*," &c.

in contradistinction to the breaking light of morn. The keen eye of M. Goldschmidt was able to detect, at the last appearance, a faint offshoot from this mysterious light, and which was observed on the same night at a different part of the world. To those endowed with sharp vision, the systematic observation of the direction and dimensions of this object would be a matter of much value. (See the accompanying engraving of a large spot, and the *faculæ* visible in February.)

One of the Elizabethan dramatists says, "Better to bless

the sun than question why he shines." Notwithstanding this, how many conjectures have been formed on this subject! Our forefathers, who were ignorant of the voltaic pile and electricity, attributed the light and heat of the sun to material fire. May there not be other agencies unknown to us which would explain the incandescence of the sun? An eminent authority, whilst favouring the idea of a perpetual electric discharge, frankly confesses that every discovery of this kind seems "to remove further the prospect of probable explanation." In addition to the energetic action of the currents of the galvanic pile, other remarkable ideas have been started. It has been demonstrated by Thompson and Watherston that if five pounds of cosmical matter were to fall on each square foot of the solar surface, and the body was going at the rate of 390 miles per second, that the heat and light resulting from the shock would be sufficient to account for that actually existing on the sun. Those falling bodies must be searched for in the shooting stars, and probably in the zodiacal light. Messrs. Carrington and Hodgson have witnessed a phenomenon which favours this conjecture (a portion of the solar surface blazing suddenly for an interval of about ten minutes), yet the theory which attributes the lustre of the sun to the continual formation of torrents of electricity engendered by the clouds of the various envelopes, would seem to obtain the greater number of suffrages among astronomers.*

It might be added that, as the northern lights sensibly affect the magnets, it has been noticed that the phenomena connected with the sun also appear to exert a certain influence on them. General Sabine has shown that the maximum variation of the needle corresponds with the greatest abundance of the solar spots. The dependence of the magnetic intensity on the solar altitude is well known; and it has also been found that the earth's magnetic force is greatest at those seasons when our globe is nearest the sun. Admiral Smyth may well say, on this subject, that a "wonderful coincidence seems to be satisfactorily established therein, a mine is sprung, the extent of which he is a bold man who will venture to predict, although inductive experience is allowed to adopt the tone of prophecy."

* Professor Thomson considers that meteoric action is the only explanation which can be given in respect to the heat and light radiated by the sun. Chemical action is insufficient to account for it, whilst meteoric action depends on independent evidence. The former could generate only about 3000 years' heat, the latter would account for twenty million years of solar heat. And what a degree of heat too—sufficient to keep up a 63,000 horse power. Each square yard of the solar surface representing the consumption of 13,500 pounds of coal per hour, and where forty feet thickness of ice would thaw per

It will be seen that the various phenomena of spots, whether dark or brilliant, and all the different changes in their form and motion and number, are not mere objects of idle curiosity, but intimately connected with the economy of our own globe. Should the persevering observer merely count the number of spots which he remarks on the solar surface in the course of a year, he would confer a boon on science. If, in addition, he accurately determines their positions by Mr. Carrington's plan, the series of observations would be extremely valuable. That eminent observer has discovered a law of storms in the sun's atmosphere, there being a daily drift of the spots in longitude which reveals a general equatorial current of thirty degrees in breadth in the direction of rotation, whilst a reverse current of nearly the same breadth is perceptible beyond it in each hemisphere. We are indebted to M. Schwabe for a systematic reckoning of the number of spots visible since 1826. In 1828 the number of groups was 225, which gradually diminished to 33 in 1833. In 1837 they had increased to 333; and in 1843 they had fallen to 34. By 1848 the number had again increased to 330; whilst in 1856 only 34 were visible. In 1860 they had increased to 210; and in the years 1861 and 1862 will, doubtless, be greater. It must be remembered that all these changes are gradual. The periodicity is undeniable, and may be reckoned at about eleven years, though it does not appear to be constant, sometimes amounting to nearly fifteen years (as the minima of 1784 and 1799), sometimes being only 8½ years (as the minima of 1689 and 1698). The observer will perceive, too, that the zones of disturbance are different year by year: sometimes the spots are confined wholly to the sun's equator; at other times wholly north, sometimes altogether south of the equator. They seldom pass beyond forty degrees of latitude. That they are intimately connected with the rotation of the sun on its axis there can be no doubt, but that it is solely due to this cause is impossible. There must be external atmosphere or internal agitation to cause those immense ruptures (one of which was measured at 3,780 millions of square miles in area) which precedes the effect produced by rotation. The amateur astronomer will see what a rich field is

minute. At the Cape of Good Hope, under a vertical sun, only one inch of ice would melt in 2h. 12m. 42s. It may be added that according to the theory of Mr. Watherston, the *debris* and fragments of broken material which would fall and batter into the sun would (if of the density of granite), cover the surface to a depth of twelve miles annually, whilst according to the hypothesis of Professor Thomson, a thickness of twenty-four miles would fall into it, from the matter of the Zodiacal light coming in contact with its photosphere.

opened to him in the path of discovery by diligent observation of the solar spots alone, remembering

> "No earnest work
> Of any honest worker, howbeit weak,
> Imperfect, ill-adapted, fails so much
> That 'tis not gathered like a grain of sand
> To enlarge the sum of human action used
> For carrying out God's end."

Strange to say, it is when the sun is entirely hidden from view (as during the darkness of a solar eclipse) that we become best acquainted with its clouds, its atmosphere, and the general phenomena of its surface. Look at those two illustrations representing the appearance of the sun, or rather the light surrounding it, and the moon at the last two solar eclipses of 1858 and 1860. What strange forms are beheld in the halo or glory about the moon! What are those crimson flames? Are they our old friends the bright streaks of light—the faculæ? Is it this corona or glory which is the suspected outer atmosphere of the sun, and which causes that dimness of the sun's light towards the margins which has been already mentioned? Does it buoy up and float those cloudy protuberances for some forty or fifty thousand miles above—not the real surface, but the outer photosphere of the sun? These are questions which, notwithstanding that they have been critically observed during the solar eclipses of 1842, 1851, 1858, and 1860, still remain undecided. Some *savans* hold that they are purely optical, caused by the sunlight striking the edges of the moon—the effects of that phenomenon in optics known by the name of *interference*, *i. e.* when light passes by any rough edge, and produces certain coloured fringes to the ray which is received on a screen. Are those ruddy prominences produced in this manner? In the first place, they are too sharply defined to have their origin in this way; in the second, they have been seen to *increase* in length as the moon passed *away* from them, and to decrease in dimensions as the moon passed towards them. This circumstance, which was confirmed by many observers, would seem to be conclusive of their being part of the real body of the sun, that the red flames are the faculæ, that the corona is the luminous atmosphere of the sun. But how are these strange rays of light produced in the corona? How are we to explain that they appeared on the left when total darkness commenced, and to the right when the moon was leaving the disc of the sun? The Astronomer Royal is of opinion that the atmosphere of the earth extends all the way to the moon, and that the light is reflected by this atmosphere. There are methods even of detecting whether such is the case, and in the present instance

it was found that the light from the corona was reflected light, and reflected too by the atmosphere of the earth. Another celebrated astronomer, at the same time that he believes in the existence of an atmosphere around the sun, still considers that the extraordinary rays of the corona are optical; and he has even been able to produce them artificially, by introducing a circular screen between the eye and the rays of light coming through an aperture in the walls of a dark chamber. But so many discrepancies exist between observers, that it is quite impossible to reconcile the accounts. Red prominences were seen by one observer which were quite invisible to his neighbour. Protuberances which were seen red at Miranda were seen white at Valencia. The rays of the corona at two different stations at the same moment were in different directions. Strangest of all, the decrease of the eastern protuberances, like the increase in the western, were more rapid than the moon's motion would allow of. There can be no doubt, too, but that the rays of the corona were seen curved, intermixed, and even tangential to the edge of the moon. We may state that the illustrations have not been selected by us on account of their eccentricity: both drawings have been made by very eminent observers—the one of the eclipse of 1858, by M. Liais; and that of 1860, by M. Feilitzch, who had previously observed the eclipse of 1851. The latter observer noticed that the corona was much brighter in the last eclipse than in that of 1851.*

The most trivial incidents during a total eclipse of the sun are watched with the greatest interest, particularly during those few moments when total darkness overspreads the earth. Having been stationed near Reynosa, in Spain, in company with Messrs. Buckingham and Wray, the writer was able to observe the last eclipse of 1860. First comes that gradual march of the moon over the sun, which latter, even when half obscured, is not sensibly diminished in lustre. Then the gradual waning of the crescent of the sun, until it is reduced to the merest thread of light, and then the obscurity begins. The thread of light is irregular, as we see by means of the telescope, and whilst we are looking at it (now invisible to the naked eye) we notice that it is broken up into fragments, brighter than stars and somewhat resembling electric sparks. Now, between the broken sparks, the first rays of the corona break out with the brilliancy of a glory; in another moment, the sun is completely hidden; the dark velvet surface of the moon is seen projected on the silvery corona, and all is in obscurity—a darkness not complete like that

* For remarkable differences of drawing we refer to the diagrams in the Astronomer Royal's Lecture as given in the *London Review* of September 21, 1861.

of night, yet something altogether different from twilight or the gloom of a rainy winter evening. The scenery around was illuminated, not only by the light of the corona, but by the more remarkable light which was seen in the southern horizon. For an altitude of some fifteen degrees, towering above, and in the direction of the plains of Castile, we saw the most glorious crimson and yellow tints colouring the sky and meeting the dark-blue clouds above in a rich purple. The effect was magical —almost similar to the earth illumined by a splendid aurora; or, rather, imagine passing from the brilliant sunshine into a Gothic cathedral, where the dim religious light enters through richly-coloured oriel and lancet windows—one may thus have a faint idea of the gloom—singular and terrible at the same time, which is produced by a solar eclipse. The hushed whispers of those around who pointed to some bright star or planet overhead, added to the solemnity of the scene and the sombre faces of the worshippers, put one as much in mind of the countenances of the witches round the caldron in "Macbeth" as of the witnesses of a great natural phenomenon. When the darkness was at the greatest, the wind moaned with a melancholy souud "le vent de l'éclipse," our neighbours call it, and did not serve to raise one's spirits. The pigeons rushed to their dovecot—butterflies fell down as if dead—a vulture seated on a rock on a neighbouring hill dropped as if shot—a group of goats formed into line and marched in the direction of home—the matutinal chants of chanticleer were intermingled with the sounds proceeding from the maternal cares of the feathered domestic tribes of the farmyard in which we were situated. Such effects of the darkness came under our own notice. And although we found that the boasted clearness of "le beau ciel de l'Espagne" was rather a myth and might be aptly compared to the famous "châteaux d'Espagne" (*Anglicè*, castles in the air), yet we did not think our journey from the banks of the Seine, across the Loire, the Garonne, and the Adour, altogether lost, even although we came across much unfavourable weather near the source of the Ebro; and met not only with snow to the depth of eight feet on the mountains (in the middle of July), but with solid mist and fog which could only be paralleled in November in London. Although we perfectly perceived the corona, yet it was too cloudy to detect the ruddy prominences; so that our evidence is negative in this respect, and it proves that the first-named was brighter than the latter, which some observers deny. The broken crescent, if not the Baily beads, were seen to great advantage by Messrs. Buckingham and Wray, as well as by the writer, and the extraordinary brushes of light from the corona, crooked and intermingling with each other, were likewise plainly visible to all the party. We have heard of Spaniard and Moor

crouching with terror during the darkness; but although we were in the midst of a crowd of the former nation, and a rural population too, we did not see it, and can scarcely believe it. As many discrepancies exist, however, between the statements of ordinary observers as between those who looked at the solar phenomena through a telescope. To one observer the darkness appeared to last for only two minutes (it was upwards of three); to another, such was the sense of oppressiveness, that the interval between the disappearance and reappearance of sunlight seemed to endure for two hours!

These are a few of the phenomena connected with the orb of day, the source of light and heat in our system of worlds.

LIGHT AND COLOUR.

BY ROBERT HUNT, F.R.S.

THE earliest truths, taught us in the oldest Book, are, that when darkness was upon the face of the deep, the Earth was without form and void; and that, after the creation of Light, the surface of this planet was speedily covered with organized forms, rejoicing in the fulness of life.

Man, through all time and in every country, has given expression to these truths. Light and Life—Darkness and Death—Light and Truth—Darkness and Falsehood, have constantly been associated in the human mind as relative terms. Every mythology has shadowed forth in some of its impersonations the connection of the Sun and its golden glories with all that is living and beautiful on the Earth. The Heaven of man has always been a realm of Light, and Hell a region of the deepest gloom. The Sun has, from the earliest indications of mental effort, been the object of religious contemplation amongst men, and through long periods of time, that orb has been the centre of their sincere, though mistaken, adoration. The highest efforts of pure thought which distinguished the refined philosophy of Greece leads but to this end, and Plato's sublime expression, God *is Light*, forms the sum, as it were, of the mental power of this refined people.

Advancing beyond this point, by the aids of inductive science, the moderns have been taught by their philosophers to regard the Sun as the source and centre of mighty Forces, upon which depend the great phenomena of terrestrial creation, and to see far beyond and above it the Omnipotent Creator.

The Sun is not to us an object of adoration, because by the increased penetrating power of our mental vision we are rendered conscious of agencies beyond the Sun, by which that orb with all its attendant worlds are regulated. Light is not a god to us, because we believe Light to be but one of the manifestations of Creative Wisdom. We burn no fires upon our hills as symbols of the sacred solar fires, because man has discovered that the vivifying forces of the sun-beam, are but indications of the transformation of matter taking place in obe-

dience to laws of the same order as those which produce Light and Heat on the Earth.

Although, however, we have ceased to adore the "Central Orb of Fire," we still regard the Sun with feelings of wonder. If our minds are freed from the thrall of superstitions by the development of some great truths, they are still struggling in the uncertainties of our imperfect knowledge, and seeking a deeper, a clearer insight into the vast phenomena which are opening upon our knowledge.

In the absence of the Sun there is night, and when the Sun's disc is obscured during an eclipse, notwithstanding the Light reflected from the sky, dark, unnatural shadows fall around us, and the colours of objects pass into neutral tints. These facts convince us that Light is derived from the Sun, and that the brilliant colours with which Nature is adorned are directly dependent upon luminous radiations.

The reader, it may be, sits in a room, the decorations of which are in brilliant colours, the furniture to match is of the richest dyes, and, let us suppose, the most brilliant flowers of the garden have been arranged around to add to the chromatic beauty. If the Light is gradually excluded, each object loses its colour, and eventually, if the darkening is proceeded with, all becomes black.

Another experiment is, however, necessary to carry conviction to the mind that the surfaces so richly tinctured are themselves colourless, and derive all their brilliancy from the physical condition by which some rays of Light are absorbed, while others are sent back to the eye.

We possess the power of producing flames which emit but one colour. Dry table-salt, if burnt in a gas-flame, or if it be mixed with spirits of wine and ignited, burns with a pure yellow light. If we make an experiment in our variedly-coloured room, excluding, of course, the daylight, every object which does not possess the power of sending back to the eye yellow rays, will, there being no other rays, appear of a dull neutral tone, or become absolutely black.

The brilliant red fire of pyrotechnic exhibitions is produced by strontian. If this salt is burnt, instead of the table-salt (*chloride of sodium*), all the yellows and greens disappear, and those surfaces only which reflect red are seen in colour.

The labours of the artist, the skill of the decorator, the technical skill of the dyer, have one end. They aim, each of them, at producing surfaces which shall act differently upon the incident rays, and thus produce different sensations on the organ of vision: those sensations which we call colour being dependent on vibrations communicated through the optic nerves to the brain; these luminous vibrations present-

ing a certain analogy,—but nothing more,—to the undulations of sound, which convey to the seat of sensation the impressions of musical harmony.

The hypothesis that Light is the result of vibrations, established by solar influence on some ethereal medium existing throughout planetary space, is now almost universally received. It is quite certain that by far the larger number of the phenomena of Light will admit of explanation, in a satisfactory manner, by this hypothesis only. At the same time, it must not be disguised that the most zealous advocate of the theory of luminous undulations, has failed to show that there is any support given to his views by the chemical phenomena of Light. It is not intended by this remark to suggest a doubt against a doctrine so ably supported; but it does appear necessary that there should be found in our philosophical records, at least, an attempt to show how chemical changes—photographic phenomena—are connected with undulatory motion.

That Light travels with immense velocity is evident to all. The flash of Light from a distant gun reaches the eye long before the sound of the explosion is communicated to the ear. To measure this velocity it is necessary that we should have the means of examining the passage of a ray of Light through vast distances, and this has been done by careful observations of the eclipses of the satellites of Jupiter.

Roemer, a Danish astronomer, in 1675, on comparing together observations of eclipses of these satellites during many successive years, observed that the eclipses when Jupiter was nearest to the Earth took place *too soon*, whereas when those two planets were at their greatest distance apart, the eclipses were always *too late;* that is, the eclipses of the moons by the planet were, according to the distance from the Earth, either sooner or later than by calculation they should have been. Speculating on the physical cause of this, Roemer was led to believe in a gradual, instead of an instant propagation of Light, and the velocity required to explain these differences between observation and calculation was 192,000 miles in every second of time. This has since received the fullest confirmation. Bradley, by his discovery of the *aberration* of light (the apparent displacement of a luminous point by the onward motion of any spot on the Earth's surface), has given us the means of proving that the error, if any exists, is an exceedingly small one: the most accurate determination giving 191,515 miles as the velocity of Light in a second. This is a speed which it is difficult to realize to the imagination. The greatest velocity which has been attained by locomotive engines, in some experimental trials on our railways, has been 100 miles within the hour. If we were to start at this speed from

the Earth and travel towards the Sun, and be enabled to maintain this speed through the entire space between us, we should require more than 108 years to complete the journey, and yet a ray of Light passes over the same space in seven minutes and a half.

If the reader will place himself in a dark room, of course objects are invisible to him; there is a negation of colour, because there is an absence of Light. Pierce the shutter with a needle, a thread of Light flows into the room, forms a round luminous spot of *white* Light on the floor; from this point radiation is established, and the eye begins to distinguish objects and to be sensible of colour. The phenomena of vision, and the phenomena of colour, are therefore proved to be dependent on the presence of the sun-beam.

If we take a triangular piece of glass (a prism), and place it so that the Sun-ray falls upon one of its angles, a new phenomenon results. A ray of Light, in passing from any medium into another of a different density, is bent out of its path, or undergoes refraction. The degrees of refraction are dependent upon the varying thickness of the mass, so that our wedge of glass presents a gradually thickening transparent medium to the rays. By this the Sun-beam, which enters the prism, of the most transparent whiteness, or colourless, leaves it a sheaf of rays intense in the brilliancy of their varied colours. The spectrum so formed, if received upon a screen, will be of a flame-like shape, and, commencing at that end where the ray is least bent, we have the following order in our chromatic scale: red, orange, yellow, green, blue, indigo, and violet. This image (which was represented in our last number, in connection with the dark lines by which it is crossed) has been called the Newtonian Spectrum, for to Newton we owe the first careful investigation of the phenomena. That philosopher determined the number of primary rays to be, as above enumerated, seven. Sir David Brewster, however, reduces the number to three: red, blue, and yellow; and from these he argues that all the infinite variety and beauty of colour which we see in nature must be derived by intercombination. Fig. 1 represents the principle of this; the three primary colours are in the corners of the equilateral triangle; green, orange, and violet, are produced by the combinations of the nearest two of these, and the neutral tint of the centre is the result of combining the three colours. This appears to require that a very prevalent error should be noticed. It is often stated that by combining pigments of the colours of the spectral rays, *white* is produced. Nothing can be further from the truth, as *black* is the result of the experiment.

It is undoubtedly true that if we recombine the rays of the

spectrum which have been separated by prismatic analysis, we produce white Light. But the statement that a disc painted in correct proportions of the primary colours will, if rapidly rotated, appear white to the eye, is far from correct. If a white circle is left in the centre of such a disc, as represented in Fig. 2, it will be seen that the combining colours, when in motion, produce, at the greatest velocity, a grey. It must be borne in mind that this is not the result of any combination of the colours, strictly speaking. The intensity of sensation produced by the different rays varies greatly; and when any many-coloured object is in rapid motion, those colours only which are the most intense, impress themselves on the retina; and from the persistence of the images so produced, the effect obtained is due only to some two or three of them.

The experiment is ever an interesting one; it may be studied with great advantage by means of Gorham's colour top, which philosophical toy becomes exceedingly instructive, when properly employed, in illustrating the phenomena due to the blending of either compound or primary colours in sets, and the persistence of one colour in close comparison with another.

To return to the spectrum. Beyond the seven bands of colour described by Newton, we may see some others which were unknown to him. Having, in our dark room, obtained a brilliant spectrum, if it is looked at through a piece of cobalt blue glass, a beautiful *crimson ray* is apparent below the red. If the spectrum is thrown on a piece of paper stained yellow by turmeric, a *lavender grey* ray becomes visible beyond the violet. If the spectrum is received upon a plate of glass stained of a canary yellow by uranium, a pale-green ray is seen beyond the lavender grey; and if we throw the spectral rays upon a solution of sulphate of quinine, we see celestial blue rays near the same spot. The rays last mentioned, have been called by Professor Stokes, who has fully investigated their phenomena, the fluorescent rays, from the circumstance of their being seen in great beauty in many specimens of fluor spar.

From this statement it would rather appear that the coloured rays are more, instead of less, than seven.

Sir David Brewster has been led, from his extensive investigations, to infer that the spectrum which we see is really three spectra overlapping each other; that the pure colours are seen at certain points of maximum effect, as red, yellow, and blue. Where the red and yellow blend, orange-coloured light is seen; and where the blue and yellow mix, green is visible. It happens, however, unfortunately that we cannot produce green by mixing a pure ray of blue Light and a pure ray of yellow Light. Under this difficulty many of the continental philosophers con-

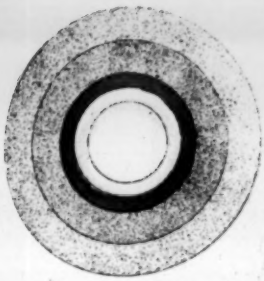


FIG. 4.

FIG. 3.

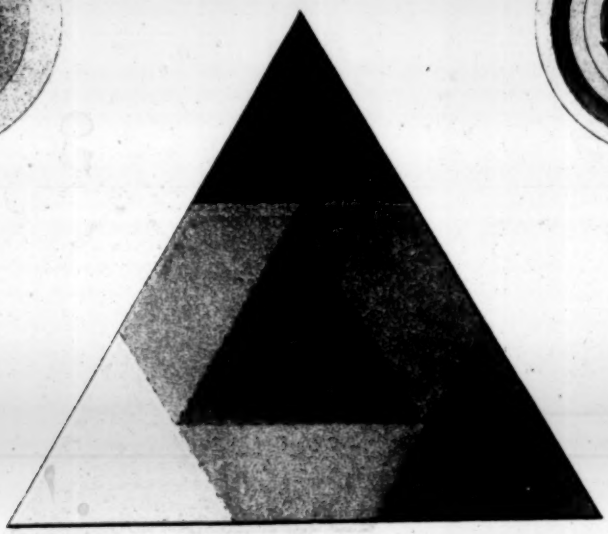


FIG. 1.

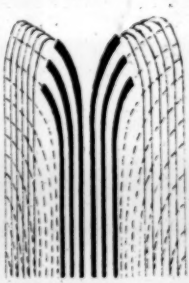


FIG. 5.

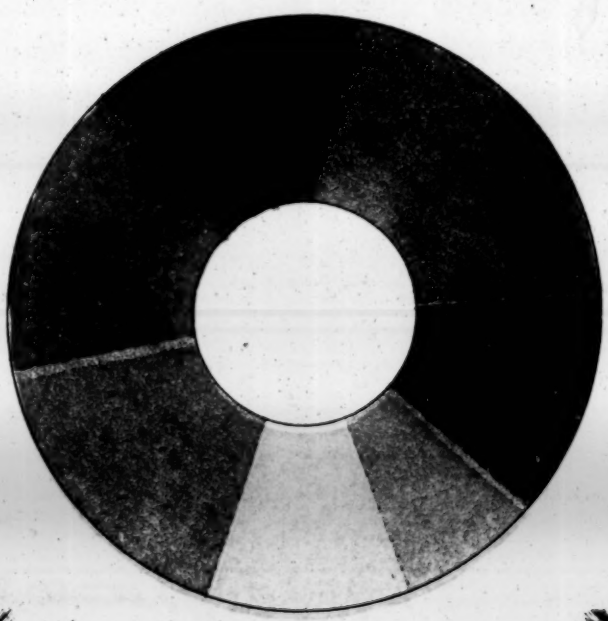


FIG. 2.

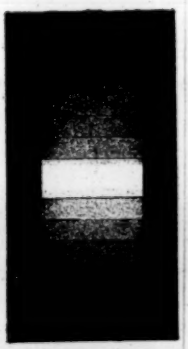


FIG. 6.

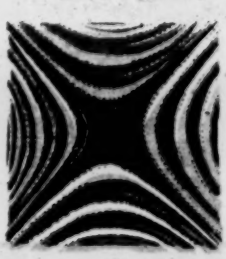


FIG. 7.

FIG. 8.

LIGHT AND COLOUR.

sider green as a primary colour, consequently making their actual number four.

This is not the place, however, for discussing this delicate question; we have chiefly to prove that colour has no existence without Light. Another evidence of this is given in the colours of thin films. A soap bubble blown by a child, and floating in the sun-beam, becomes a study to the philosopher. If we mix soap with a solution of sugar in water, we may give considerable permanence to the filmy globe, and study all its beautiful changes, as the thickness of the film varies. A drop of colourless oil let fall upon water spreads out in a thin veil, and sends to the eye a glorious series of colours. Even films of air do the same thing. If a plano-convex lens is placed on a convex lens it is obvious that they can only touch at one point, and that films of air varying in thickness surround that point. The result of this is a system of circular coloured rings. They are of one set of colours when seen by reflection, and of another set when viewed by transmission. Looking *at* those rings, they will be in one condition, as shown in Fig. 3. Looking *through* them, they will appear as in Fig. 4, or complementary to the first. These remarkable colours vary with every variation in the thickness of the film of air.

Another illustration of the dependence of colour on Light is produced by passing the ray of light admitted through our pin-hole in the dark room, near the edge of any body. This effect is termed the inflexion of Light, or diffraction. If a short-focus lens be placed in the hole through which the Light is admitted, the effect is more intense. If a needle be held in this beam, its shadow will be found to be surrounded with three fringes: the first giving all the colours of the spectrum; the second, blue, yellow, and red; and the third fringe, pale blue, pale yellow, and pale red. It is impossible to represent these fringes by artificial colouring; but the beautiful curves formed are shown in Fig. 5. If the ray of Light be received on a glass rod blackened, and we look at it through a fine slit in a card, the appearance will be, as shown in Fig. 6—white light occupying the centre of the whole, and spectra separated by black lines extending on either side.

The colours of fibres and of grooved surfaces are easily seen. If we dust some hair-powder or lycopodium upon a glass plate, and look through it at a candle, the flame will appear surrounded by a halo. Fibres of silk or wool, spread out closely together, give rise to similar coloured rings. The colours of mother-of-pearl are due to the infinite number of fine grooves upon its surface. If we melt a little white wax, and pour this on the mother-of-pearl, it receives impressions of those fine grooves, and, if removed, when cold it will be as iridescent as the shell

itself. By drawing a series of exceedingly fine lines on steel, or any other metal, we may produce the same phenomena. Iris ornaments or Barton's buttons are obtained by cutting such fine lines on the surface of polished steel.

Space will allow only of our referring very briefly to the splendid chromatic phenomena dependent on the Polarization of Light. In some future number we may possibly be tempted to enter more at large into this fertile field of inquiry. To take the most simple form of illustration:—If we receive a ray of Light upon a plate of glass placed at an angle of about 56°, a portion of the ray is transmitted, and a portion is reflected. Now, if we place a blackened mirror, to receive the reflected ray, it will be found that the ray has undergone the change which we term *Polarization*. If a slice of sulphate of lime or mica be placed between the two and we observe its image in the black mirror, we shall see a series of colours such as are shown in Fig. 7; while, if this is turned round a quadrant of the circle, these are changed, and appear as represented in Fig. 8.

Brief and necessarily imperfect as this description of the phenomena of colour has been, it is hoped that the more important physical states upon which the production of colour depends will have been rendered intelligible.

All colour is dependent upon Light. Every variation in tint or hue is determined by the physical condition of the surface upon which the incident Light falls. Reflection, absorption, refraction, diffraction, and polarization, are all engaged in producing that exquisite display which adorns the fields of Nature, and which is so effective within the domains of art.

THE GREAT EXHIBITION BUILDINGS.

BY WILLIAM FAIRBAIRN, LL.D., F.R.S., ETC., PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, ETC.

THE introduction of the use of iron in buildings has been a great desideratum for the last twenty years. For nearly a century, iron has been employed in the construction of steam-engines and machinery; and as improvements have from time to time been made in its manufacture, and confidence has been gained through experience in its use, it has gradually usurped the place of other materials in millwork, in shipbuilding, and for bridges. But its application to dwelling-houses and public buildings has been retarded by a want of the requisite knowledge on the part of architects and builders, and a determination in many quarters to resist its introduction as an innovation upon the good old practice of employing brick, stone, and timber, for such purposes.

To ensure economy and success in the introduction of iron as a building material, the architect should make himself acquainted with its properties in its cast and malleable state, and he must commit to memory certain facts which bear upon the comparative resisting powers of these two materials under various kinds of strain.

An example of the knowledge which is indispensable to architects and builders desirous to be considered proficient, will be found in the following data:—

	Tensile Strength per square inch in lbs.	Compressive Strength per square inch in lbs.	Transverse Strength per square inch in lbs.
Cast Iron	16,500	112,000	40,000
Wrought Iron ...	51,000	38,000	42,000

Thus, it will be observed, that whilst the *tensile* strength of wrought-iron is three times as great as that of the cast metal, its resistance to crushing is only about one-third as great; and these facts point to the effective and economical employment of wrought-iron as ties, and in similar cases where tensile forces have to be resisted, and to the use of cast-iron for columns and framework, where the desideratum is to withstand the power of compression.

Again, the architect must be aware of the different arrange-

ments necessitated by the varying properties of these materials. A cast-iron beam, for example, should have its bottom flanch * six times the area of the top one, or, in practice, at least four times, to suit the convenience of casting.

On beams of *wrought*-iron, on the contrary, a different arrangement is necessary, the area of the top flanch requiring to be nearly double that of the bottom,—to attain a maximum power of resistance. In large wrought-iron girders for bridges, the construction is again modified by the introduction of tubes or cells in the upper flanch, as in the Conway and Britannia bridges, when the areas should be proportioned in the ratio of 11 to 12. Again, it should be understood, that the strengths of girders of similar proportions increase as the squares of the span, whilst their weights increase as the cubes of the span.

With these preliminary observations, it may be interesting to glance cursorily at the history of the application of iron to constructive purposes down to the present time, when it is most strikingly exemplified in the works in progress at South Kensington.

The exact time when cast-iron came into use appears to be very uncertain, although for the casting of cannon and other purposes it has been employed from an early date. It was not, however, till 1794 that John Rennie applied it successfully to millwork, in the machinery of the Albion Mills, Southwark. It was employed for bridges as early as 1777, by Mr. Pritchard at Colebrook Dale.

The first notice we have of its application to buildings, was the use of cast-iron beams at Messrs. Philips and Lees's cotton mill in Salford, in 1801. These beams, extending from wall to wall, were supported in the middle by cast-iron columns and carried brick arches to form the floors, which were consequently fireproof. For half a century this same principle of construction has been successfully followed and applied to nearly the whole of the factories of Lancashire and Yorkshire.

In the use of cast-iron there is, however, a hidden source of danger, arising from flaws in the castings, want of proportion, &c., and several serious and fatal accidents have resulted from this cause, as well as from ignorance of the properties of the material. Hence we earnestly recommend the more extensive application of wrought-iron in every case where tensile strains have to be resisted. The breakage of cast-iron beams not only involves the destruction of property, but, what is far more serious, a great sacrifice of life, of which the accident at the Hartley Colliery is a fearful example; and this

* The flange or flanch is the projecting ridge at either side of the beam.

question is, we believe, at the present moment engaging the serious attention of the Legislature.

The first house entirely built of iron was, we believe, constructed by the writer's firm, at Millwall, London, in the year 1840. It comprised a flour-mill, three stories high, with cast-iron pilasters at the corners and sides, with intermediate plates of sheet-iron. The interior was plastered upon wire gauze, leaving a space of three inches between the plaster and the external plates, to secure uniformity of temperature within. This mill was constructed in sections, and shipped, along with its steam-engine and machinery, to Constantinople, where it still exists. In subsequent years some few houses were constructed of corrugated iron plates, and the discovery of the gold-mines in California and Australia created a considerable demand for these, so that hundreds of houses, and even churches, warehouses, &c., were despatched to these remote countries.

Such was the history of our iron constructions up to the year of the Great Exhibition of 1851, when a new era in the application of iron dawned upon us, taking its rise in a rude sketch executed by Sir Joseph Paxton whilst travelling from Chatsworth to London. It is well known with what success this unique structure of glass and iron, so happily conceived, was ultimately erected. This was the first colossal building of iron; next followed the Crystal Palace at Sydenham, and subsequently the Art Treasures Exhibition of Manchester and the Exhibition at Paris, of the same material.

These structures are, however, likely to be eclipsed by the gigantic buildings of the same character in progress at South Kensington; and it is in reference to these that we shall now attempt, without entering into a scientific analysis, to give some reliable data which may afford to our readers a clear perception of their magnitude, and of the purposes for which they are destined.

The deep interest which the lamented Prince Consort always took in every movement calculated to promote the education and improve the condition of the people of these islands is proverbial; and his increasing desire to raise the standard of taste in the industrial as well as the fine arts is so well known, that his premature removal has been universally regarded as a national calamity. It is no wonder, therefore, that the nation looks forward with some anxiety and with great hope to the success of the forthcoming Exhibition, as a kind of memento of the services and encouragement which have been lost to it through that heavy bereavement with which it has been visited, in common with her Majesty.

In the building itself, which covers an area of nearly twenty-

five acres, will be found articles of every possible description, and her Majesty's Commissioners have spared neither labour nor expense in making ample provision for the extraordinary demands that have been made upon them. It was found, however, that seven times the space provided, gigantic as that is, would be required to meet all the demands of the exhibitors, and the Commissioners have been compelled reluctantly to cut down the allotments, in many cases, to one-third or one-fourth of what was required by exhibitors.

The most prominent feature of the original design prepared by Captain Fowke was a Great Hall, 500 feet long, 250 feet wide, and 210 feet high, behind the principal entrance on the south side. The cost of the building, as then estimated, was £590,000, which exceeded the means that the Commissioners could reasonably expect to have placed at their disposal, and the Great Hall was, therefore, abandoned. The general plan of the present design consists of a great Nave with Transepts at each end, whilst at the intersection of these are the two immense domes, which form the chief features of the east and west fronts. The nave is 800 feet long, 85 feet wide, and 100 feet high, or four feet less than the great central transept of the Exhibition of 1851. It is supported by coupled cast-iron columns, fifty feet high, and at distances of twenty-five feet apart, on which rest the great arched ribs of the roof and the horizontal girders of the galleries, as shown in Plate XVIII., Fig. 1.

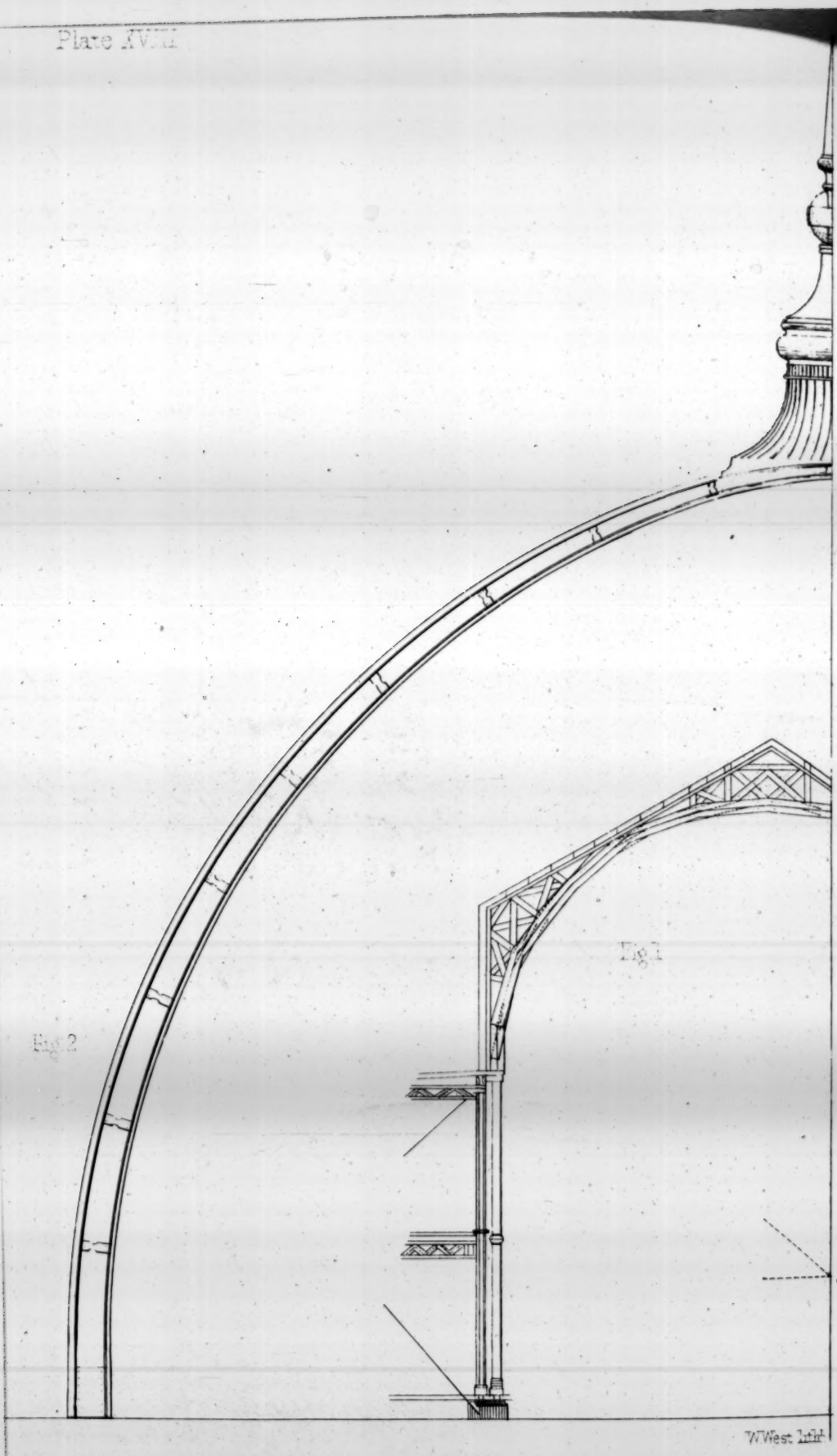
The Picture Galleries, the finest and most extensive in Europe, are permanent buildings of brick, 50 feet wide and nearly 1,200 feet long. They extend the whole length of the Exhibition facing the Cromwell-road, and form a magnificent series of apartments. The principal entrance to these spacious galleries is through a hall, 150 feet long by 110 feet wide, leading to the inner courts, and also to the stairs which conduct to the galleries above and diverge from the entrance on either side.

In the designs for the galleries great care was taken in regard to light and ventilation, so essential to the inspection and preservation of pictures. On ascending the stairs, the visitor enters a vestibule of the same proportions as the hall below, and from this point is obtained an unbroken vista through the whole extent of the gallery; and it is difficult to conceive a more imposing effect than the noble proportions of the galleries on both sides.

An eminent writer, in describing it, states that—

"On entering the front, on either side the visitor will find himself in a spacious hall, 325 feet long, 50 feet wide, and 43 feet high. Passing through this, he will enter one of the wing towers, which forms a room 52 by 45 feet, and 66 feet high; he will then enter another room, 75 feet long and of the same width and height as the first, from which he will pass into the end

Plate XVIII



Sections of the Nave & Dome
Great Exhibition Building. (1862)

tower, where he will have an uninterrupted view of the whole main gallery. The interior decoration of these rooms is very simple, and may be briefly described as a plain cove extending to each side of the skylight, and resting on a moulded cornice."

Thorough ventilation is amply provided by the admission of air through apertures at the level of the floor, and allowing the vitiated air to escape through louvres* in the skylights above. The lighting of the gallery is very successful, and the important point gained is an equal distribution of light, so as to prevent any reflection of rays from the picture to the eyes of the spectator. This has been successfully accomplished, and there is every reason to believe that in any position where the spectator may stand, the pictures will be seen with the best possible effect.

The galleries, which extend along both sides of the nave and transept, are supported by cast-iron girders, which rest on the double columns, which ascend to a height of fifty feet from the floor, and from which spring the principal arches of both nave and transept. These girders are at right angles with the line of the nave and transepts, and rest on single columns twenty-five feet high under the centre of the fifty-feet wide galleries, and on those which surround the spacious courts on both sides of the nave. They are formed of a series of equilateral triangles, which unite the lower and upper flanges, and are calculated to support more than four times the load that ever can be brought upon them by a crowd of people closely packed. Between the transverse cast-iron girders the joists and flooring are supported by wooden beams trussed with iron rods; and on these and the front iron beams (to which is attached handsome railing on both sides surrounding the nave and courts), are placed the joists and boarding, forming an extent of upper-gallery accommodation equal to *one mile and a half in length*, and varying from fifty to twenty-five feet wide.

The upper girders which support the flat roof, covered with felt and zinc, are of lighter construction than those below, but of sufficient power to resist four times the weight to which they can ever be subjected. The level of the flooring is five feet below that of the surrounding streets; and the object of thus sinking the floors is to obtain a more imposing view of the building as the visitor enters from the domes at each end. He will, therefore, ascend two steps to a large platform or dais at each entrance, and from thence descend, by a flight of steps eighty feet wide, into the nave or transepts on three sides. There are four large courts: two of them 250 feet by 200 feet; two more, 250 feet by 86 feet wide; and two central courts,

* Louvre, lover, or loover, from the French word *l'ouvert*—the opening.

one 150 feet square, and the other 150 feet by 86 feet wide. All these are 50 feet high, covered with glass, and lighted from above. They are the only parts which resemble the Crystal Palace.

One important feature in which the Exhibition of 1862 differs from that of 1851, is the Refreshment-rooms and Arcades. They are built of brick, and overlook the whole of the Horticultural Gardens. Unlike its predecessor of 1851, where the refreshments were confined to biscuits, soda-water, and buns, those of the present Exhibition will be on a large scale, every description of refreshment being supplied in spacious dining-rooms 300 feet long by 75 feet wide; and the arcades on each side will be collectively about 1,500 feet in length and 25 feet in width.

The Annexe or machinery compartment, which extends along the west side of the Horticultural Gardens, is composed of four spaces, each 1,000 feet long and 50 feet wide, covering an area of 50,000 square feet. The whole of these constructions comprises a "ridge-and-valley" roof, composed of a very cheap material, and of very simple construction, namely, deal boards, nailed together in the form of arches, which spring from vertical standards of two 2½-inch planks nailed together to a height of 28 feet. These, again, support the gutter plank, where the feet of the rafters terminate, a little below the intrados of the curved arch. The roof frames are boards nailed together, and so disposed that the weight comes direct on their edges. The lower part of the roof is covered with boards and felt, and the upper part is glazed with skylights, having bearers for ventilation throughout the whole length of the three divisions.

This department of the Exhibition will be devoted entirely to machinery in motion; and, in order to give every facility to exhibitors, a large supply of steam from six 50-horse boilers, placed at the north-west corner of the Horticultural Gardens, will be conveyed in pipes laid in a tunnel the whole length from north to south, at the cost of the Commissioners. Provision is also made, by the introduction of large wrought-iron pipes, for carrying the exhausted steam clear of the buildings, from the numerous engines supplied by the exhibitors; and these again, with the necessary shut-off valves, will constitute the motive power to be employed in driving every description of machinery submitted for public inspection. In addition to the steam required for these purposes, upwards of 2,300 feet of 2½-inch polished shafting will be extended, at a height of 10 feet from the floor, for the accommodation of the exhibitors. The shafting will be supported on neat cast-iron columns, extending at convenient distances in lines along the middle of the different divisions, and of suitable lengths calculated to meet the requirements of the exhibitors and give motion

to the different machines. In fact, the department of machinery in motion being entirely separated from the other parts of the Exhibition, there will be no risk of injury to any of the more delicate articles of manufacture, nor to those instruments which require to be kept dry and free from an atmosphere charged with vapour where steam machinery is employed.

From this description, it will be seen that the machinery department will of itself be a distinct and separate exhibition; probably the most perfect of its kind ever brought before the public. It will contain some of the most ingenious mechanical contrivances of this inventive age, and, from its extent, will furnish a collection of machines employed in almost every branch of manufacture, not only in this country, but from every part of Europe and America. In this World's Fair will be exhibited competitive machinery of every description, from the most ponderous steam-engines to the delicate lace and sewing machines. How suggestive of progress to the mechanic and artizan, and how interesting, will be the comparison of these unique operations when presented to the eye of every considerate and reflecting spectator! This combination of talent and the whole cunningly devised machinery of the useful arts being employed on their respective operations, is no common sight; and it is only in this deeply interesting department that we shall learn to admire and fully to appreciate the value of the inventive powers of the present age, and the purposes to which they are applied in the useful and the industrial arts.

Exclusive of the Annexe for machinery, there is another of the same character ranging along the eastern side of the Horticultural Gardens, for the reception of agricultural implements and the larger specimens of metallurgy, mineralogy, and geology, and of heavy machines which do not require motion. To the farmer, agriculturist, and rural population this portion of the Exhibition will afford examples of every improvement that has taken place for the last twenty years; and the young agriculturist need only employ his observation in order to make himself master of what is being done to attain still greater perfection in the tillage and the increased production of the soil. Here will be found every variety of hand-plough, scarifier, and grubber; and here, also, will be exhibited various descriptions of steam-ploughs, reaping-machines, straw-cutters, &c., &c.; and the most casual observer will not fail to derive benefit from such a display of the great and important features which, in machinery alone, have changed the face of the country, and almost quadrupled the produce of the land.

Our limited space will not admit of further description; but in closing this somewhat imperfect account of the Great International Exhibition Buildings, it may be proper to advert to the security of the whole structure, which is due to the excellent designs of Captain Fowke, placed in the hands of the contractors, Messrs. Kelk, and Charles and Thomas Lucas Brothers, for execution. To these gentlemen every praise is due for the liberal and efficient manner in which they have performed their contract. The whole of the responsibility for the execution of the works rested on them and their engineer, Mr. Meeson, C.E., who prepared the working drawings to be submitted to a Building Committee, consisting of the Earl of Shelburne, the writer, and Mr. W. Baker, who undertook to act for the Commissioners in conjunction with Captain Fowke and the contractors above named.

The general features of these large structures have no claim, according to the opinions of some persons, to architectural design, but they are admirably adapted to meet the requirements of the Exhibition; and the long vista of the nave, with the domes and transepts at each of the east and west entrances, will convey to the spectator a sense of perfect harmony as regards altitude, magnitude, and general effect, seldom to be met with in public buildings. Independently, however, of architectural considerations and an imposing exterior, the great and important aim of the Building Committee was to see that every part should be made secure, and that no danger could possibly arise through a want of due proportion in the different parts, and of the needful strength in everything that might affect the public safety. On the part of the contractors every alteration and all the wishes of the architect and committee have been cheerfully and liberally conceded, and the result is the following letter, confirmatory of the trials and experimental facts arrived at in testing the resisting powers of the different floors and girders, and the great domes covering the points of intersection of the nave and transepts:—

"To the Commissioners of the International Exhibition.

"My Lords and Gentlemen,—Feeling that it would be a source of satisfaction to the Commissioners, as well as to ourselves, as members of the Building Committee, and also a due precaution for the public safety, that the gallery and other floors of the International Exhibition Building, at South Kensington, should be thoroughly proved, we undertook a series of experiments on Monday last.

"We have to report that, in carrying out these experiments, the various floors and stairs were put to a more severe test than they would be subjected to with the largest number of people that could possibly be assembled upon

them at any time during the Exhibition. The results of these experiments fully bear out our calculations on the strength of the different parts of the structure, and we feel perfectly satisfied as to the stability of the building for the purpose for which it was intended.

"The two large domes, in the strength of which we have taken great interest, were eased from their temporary support last week, and no observable settlement took place.

"The following are the particulars of the tests:—The first caused a large body of men, about 400 in number, to be closely packed upon a space 25 feet by 25 feet, on one bay of flooring; we then moved them in step, and afterwards made them run over the different galleries, and down each staircase; at the same time we caused the deflections of the girders carrying these floors to be carefully noted at several places, and had the satisfaction of finding that in each case the deflections were very nearly the same, thus exhibiting a remarkable uniformity in the construction. The cast-iron girders, with 25 feet bearings, deflected only one-eighth of an inch at the centre, and the timber-trussed beams of the same bearing placed between these girders deflected half an inch at the centre. In every instance the girders and trusses recovered their original position immediately on the removal of the load.

"We are, my Lords and Gentlemen, yours faithfully,

"WM. FAIRBAIRN,
"WILLIAM BAKER, } C.E.

"London, Feb. 13."

Before the dimensions, forms, and conditions of the columns, girders, trussed beams, and rafters had been decided upon, a long series of preliminary experiments were carried on, and it was not until the Building Committee and Captain Fowke were fully satisfied as to the security of every part, that the building was allowed to proceed. Not satisfied with these early precautions, the Building Committee resorted to the final and still more severe tests of impact and concussion as produced by marching the large body of men linked together over stairs and galleries at quick and afterwards at "double step," stamping hard on every part of the bays of 25 feet square. All these precautions have been taken to secure the public safety when placed under every conceivable condition in which they can be loaded by a moving mass of people.

Amongst the most prominent features of these buildings, and those that have created anxious consideration on the part of the Building Committee and the engineer, Mr. Meeson, are the great Domes. These large constructions (designed on a scale greater than anything of the kind had ever been done before) were carefully considered, in order to be within the limits of the estimates, and at the same time to ensure ample stability in the structures. They were originally calculated to sustain a force of 40 lb. per square foot, if such a force could ever be

applied by the most powerful tempest ever known in this country, which, however, seldom exceeds 26 lb. to the square foot.

On the whole, therefore, we are justified in coming to the conclusion that the buildings are not only secure, in so far as regards the public, but they are admirably adapted for the purposes intended; and it is our sincere wish that every other feature in the Exhibition may prove satisfactory to the Commissioners,—that their object may be fully realized in a brilliant success!

ON THE RELATION OF SCIENCE TO ELECTRO-PLATE MANUFACTURES.

BY GEORGE GORE.

PART I.

LITTLE did Gay Lussac think when he discovered cyanogen, in the year 1815, the great influence which that substance would have upon the comforts and luxuries of every-day life. Prussian blue, the substance with which laundresses colour linen, and which is composed of cyanogen and iron, was, it is true, known as long ago as the year 1704, when it was discovered by Diesbach and Dippel, in Berlin; but that this substance contained cyanogen was not known until Gay Lussac discovered it.

All experimental knowledge generally passes through three stages,—viz., discovery, invention, and practical daily working: a philosopher discovers some new fact or principle in nature; an inventor applies it to some useful purpose; and a man of business brings the invention before the public, and continues it in daily use.

Suppose that Gay Lussac had not discovered cyanide of potassium, and that it had never been discovered, it is highly probable that the manufacturing returns of Birmingham, Sheffield, and other places in which electro-plating is conducted, would be much less in amount at the present time than they are, simply because there is no other known substance with which the electro-plating of base metals with gold and silver can be satisfactorily effected.

The base of every article which is coated with a thin film of silver for domestic purposes by electro-plating, consists of an alloy of three metals—copper, zinc, and nickel; this substance, commonly called nickel silver or German silver, is chosen for this purpose, because it possesses a white colour nearly allied to that of real silver; and when the outer coating of noble metal is worn away by use, the exposed baser portions do not present the unseemly appearance that they would if a metal or alloy of another colour, such as copper or brass, had been used.

Nickel was discovered by Cronstedt in the year 1751, and

is now a metal of considerable importance in the towns of Birmingham and Sheffield; the galvanic battery was discovered by Volta in 1800, and magneto-electricity by Faraday about the year 1830. Without the discovery of nickel we should have had no nickel refineries, nor German silver manufactories; and without galvanic and magneto-electricity the extensive trade of electro-plating would never have sprung up, and the manufacture of galvanic batteries, telegraphic instruments, and especially of the immense quantities of telegraph wire now consumed, would never have existed.

These and other kindred scientific truths having become common-place facts of everyday life, we are apt to think that abstract science has had but little to do with their production, and we are thus unconsciously led to undervalue the importance of abstract scientific investigation.

It is true that many processes of manufacture have not been consequences of abstract scientific discovery, that they originally resulted from alterations made in the rudest artistic appliances, and that they have been directed and improved by the results of experience. For ages past we have been deriving the benefit of scientific principles without a knowledge of their existence; we have trodden in the beaten path of experience, ignorant of the truth that we were acting in unison with fixed and certain laws. Numerous arts and processes were in extensive operation long before the principles involved in them were at all understood; the arts of enamelling and of iron-smelting were known hundreds of years before we were acquainted with the principles of chemistry. In some instances the recorded results of daily experience in practical matters, tabulated and studied, have led to the discovery of scientific laws, but this is merely the making use of our ordinary experience for the advancement of knowledge, instead of making *special experiments* for the purpose.

It is also true that many discoveries remain a long time before they are practically and extensively applied, that some made long ago have not yet found a practical use, and persons of superficial minds, therefore, frequently inquire, "what is their use?" Their use is to assist in the development of other discoveries, and to be ready at the command of the inventor, who applies them to useful purposes. Of what use were the various abstract investigations upon specific heat, latent heat, the tension of vapours, the properties of water, the mechanical effect of heat, &c., by Black and others, but to be ready for the illustrious Watt to apply in the steam-engine? Of what use was the discovery of atmospheric electricity by Franklin, but to lead to the preservation of human life by means of lightning conductors?

It is true that many things which have appeared very promising in theory or in experiment have failed altogether in practice, but why is this? It is not that the principles of nature existed in the one case, and did not exist in the other, but that we have imperfectly understood them; that from some unforeseen circumstances we have been unable to apply them, or that we have indolently abandoned them without sufficient or proper trial.

In many cases we are unable to obtain the same conditions of success upon the large scale that we have upon the small scale; if we melt some brass in a crucible, and cover it with a layer of borax, and dip a piece of perfectly clean iron into it, the iron will receive an adhesive metallic coating; but if we attempt to coat very bulky articles, such as sheets of iron, by this process we fail, because no vessel will withstand the heat and great weight of the melted metal.

In other cases a process fails because of its too great expense; many attempts have been made to supersede steam as a motive power by means of electro-magnetism, and engines driven by that force have been constructed of five or ten-horse power; but the cost of driving them has been found to be at least ten times the amount of that of a steam-engine of equal strength.

And in other cases we fail because we attempt *at once* to carry out upon a large scale that which has only been the subject of a small experiment, instead of enlarging the process by small degrees, and adapting the apparatus, the materials, and its treatment, to the size of the operation.

That which appears very simple in the hands of an experimentalist almost invariably becomes much more complex when carried into practice in a manufactory, simply because there is then a greater number of conditions to be fulfilled. Electro-plating a piece of steel with silver is to a chemist a very simple matter, because it is of no importance to *him* whether the silver adheres firmly, is of a good colour, or is deposited at a certain cost; but with a *manufacturer*, unless *all* these conditions are fulfilled, the process is a failure.

No towns have perhaps benefited more by scientific discovery and its application to trade, than Birmingham and Sheffield,—the former in particular. The great bulk of the articles manufactured there being composed of metal, are produced and ornamented by mechanical and chemical processes, and therefore offer peculiar advantages for the application of mechanical and chemical knowledge.

Many manufacturers seem to think that because their operations are so completely routine, and have been handed down to them by their predecessors in nearly their present state, they are not at all indebted to science; but there is no

manufacture, especially amongst metals, which does not continually involve scientific knowledge.

Not only has science benefited manufacturers, but also operatives, because the extension of science to manufacturing purposes has compelled them to make themselves acquainted with intellectual subjects. Instead of remaining mere machines, mechanically performing the work set before them, they are obliged to exercise the faculties of observation and judgment in watching the results and directing the action of mechanical, physical, and chemical forces. Instead of following the blind path of experience, using unknown forces to accomplish some definite result, they pursue their labours with the aid of known and certain laws.

No man has more occasion to bless the introduction of the steam-engine, machinery, the galvanic battery, and science in general, than the working mechanic, because it has mitigated his physical toil by giving him the duty of simply directing the labour instead of actually performing it: whilst it has deprived him of one kind of employment it has provided him with something better. But a few years ago the operatives in the silver-plating trade had to lay the silver on the articles with their hands and the aid of a soldering-iron; *now*, they have simply to set their batteries in action, and watch the electricity doing it for them. In a similar manner the working engineer at his metal-turning lathe has merely to direct the action of his tools whilst the steam-engine performs the heavy labour of turning.

In the present period of scientific progress, when the attention of men of business is so frequently attracted to some new invention or discovery which appears likely, if not to supersede their particular occupation, at least to have some influence upon it, it is the interest of every such person to watch the progress of science and to seize it for his own advantage, instead of allowing others to do so, and thereby divert his trade into other channels.

No art nor manufacture is so perfect as to be exempt from the influence of discoveries and inventions, and no man can produce so perfect an article, but that by the aid of science a better may be produced.

In what consists the great success of applying science to trade?—simply the influence of demonstrable truth. We know that if we have once discovered all the laws or conditions of some improved process or result in a manufacture, the reproduction of exactly the same conditions will hereafter enable us to invariably produce the same result. In this respect science differs from empiricism, for in empirically working a process we are ignorant of the condition or laws which are operating, whilst with a scientific knowledge we understand those laws,

and can direct them to our particular purposes. In the process of electro-plating, we understand the laws of the phenomena, and can direct them so as to obtain silver of a hard or soft quality, brittle or tough, crystalline silver, &c., according to our pleasure; but if we had only an empirical knowledge of the subject, we could not thus vary the process.

The great success of coating articles with silver by the electro process depends in a very large measure upon the demonstrable fact that alkaline cyanides have a strong affinity for noble metals, and but little affinity for base metals; no other substance possesses this quality, or at least in so eminent a degree. In proof of this fact, I have twisted together two similar-sized and clean pieces of very thin wire, the one piece being gold and the other iron, and immersed the double wire in a solution of cyanide of potassium; in about six weeks the so-called "indestructible" metal, gold, was all corroded and dissolved, whilst the base and "destructible" metal, iron, was as bright and perfect as ever. Further, if two pieces of wire, the one being of gold and the other of iron, are connected with the ends of a galvanometer, and their extremities immersed in a solution of cyanide of potassium, or other alkaline cyanide, the noble metal will be found to be electro-positive to the iron; and a galvanic battery of weak power might even be constructed of those three elements, which would present the singular anomaly of generating an electric current *in an opposite direction* to that in all other cases obtained.

So great a resistance has iron, and so strong an affinity has silver to be dissolved by a solution of cyanide of potassium, that if a current of electricity is simultaneously sent through both into that liquid, the electricity will pass freely as long as there is a portion of the silver remaining, and the silver will dissolve rapidly; but as soon as all the silver has dissolved the current will be nearly stopped, and the iron, instead of dissolving, will liberate bubbles of gas.

This is precisely the condition that was required for the success of electro-plating, viz., a liquid which should not corrode (as *acid* liquids do) the articles of base metal immersed in it, and should easily dissolve and retain in solution the noble metals with which the articles were to be coated, and at the same time conduct electricity readily, and not lose those qualities by exposure to atmospheric air; alkaline cyanides are the only known liquids that fulfil all these conditions.

ARTIFICIAL PRECIOUS STONES.

BY W. G. HOWGRAVE.

SINCE Sir Humphrey Davy first discovered the diamond to be pure carbon, unmixed with any other substance, various attempts have been made by chemists to produce it, and other precious stones, by artificial means; and it may not be uninteresting to glance at some of these essays, and to see how far they have been attended with success.

But little progress has as yet been made towards the discovery of the means of imitating the natural diamond, men of science having hitherto been baffled in all their efforts to find a substance capable of dissolving carbon, the chief constituent of that crystal; and indeed, until Despretz succeeded, by the agency of electricity, in actually producing minute diamonds, the manufacture of this precious stone seemed as chimerical as that of the philosopher's stone, so perseveringly sought after by the ancient alchemists. Despretz found, that by passing a powerful galvanic current through a point of charcoal over which a platinum wire was suspended, the charcoal was volatilized and deposited on the wire in the form of minute crystals, which, on examination under the microscope, proved to be true diamonds. Since this discovery no further advance has been made towards the solution of this interesting problem.

The search after the diamond having proved so unsatisfactory in its results, attention was directed to a class of stones almost as simple in their composition going under the generic name of *corundum*. In order to understand the experiments that were made, and the difficulties attending them, it is necessary that a clear idea should be obtained of the composition and distinctive characteristics of the stones belonging to this class. I will therefore, in as few words as possible, give a description of their nature and properties.

The ruby, sapphire, oriental topaz, and several other precious stones, are all merely coloured varieties of a mineral called corundum, or white sapphire, the composition of which was stated by Chenevix to be alumina, mixed with a small proportion of silica and oxide of iron. Dr. Thomas Muir and

others proved, however, that it was pure alumina, the silica found by Chenevix being abraded from the substance in which the stones were imbedded. All the varieties of corundum crystallize in six-sided prisms, and have the curious property of double refraction; *i. e.*, causing everything that is looked at through them to appear double. Alumina, the oxide of the metal aluminium now coming into such frequent use in the manufacture of articles of jewellery, &c., was, until the invention of the oxyhydrogen blowpipe, supposed to be, like carbon, infusible by any degree of heat. In 1837, however, M. Gaudin, who had given much attention to the effects produced by this then newly-invented means of generating heat on various metallic oxides formerly thought unsusceptible of fusion, attempted with some success to convert, by its aid, the apparently infusible alumina into crystals similar to the ruby and the other oriental stones. He proceeded by submitting to the action of the blowpipe a mixture of alum (sulphate of alumina and of potash) and chromate of potash, which he placed in a cavity of animal charcoal. In this manner he obtained small portions of melted alumina, having the colour and hardness of the ruby, but which could be easily distinguished from it by their imperfect transparence, and by their not possessing the property of double refraction. All subsequent attempts to obtain crystals of alumina, coloured like the precious oriental stones, have failed in a similar manner; and this has been accounted for by the discovery only lately that the colour of these stones is not due to a metallic oxide, as had been always supposed, but to the presence of some organic colouring matter. The application of this discovery may bring us nearer than we have ever yet been to the invention of a mode of producing artificially these rare gems.

The next step in this direction was made by the manager of a manufactory of Sevres porcelain, named Ebelmen, who, ten years after M. Gaudin's experiments, found out a way of obtaining crystals of corundum, but of such minute proportions as to be of no practical use. He first discovered that boracic acid, which had been hitherto supposed to be absolutely fixed, could be evaporated by the intense heat of the porcelain ovens; upon this it occurred to him that by dissolving alumina in boracic acid, which could be done by heat, and then evaporating the liquid, it would be possible to obtain crystals resembling the oriental stones; and it was found, in fact, that by exposing a platinum capsule containing such a mixture to the heat of the porcelain oven for a considerable time, the boracic acid was evaporated, and a number of little shining crystals of alumina having the properties and appearance of small precious stones were left adhering to the capsule, but

adhering so tightly that it was found impossible to detach them entire.

One other experiment is worthy of notice before proceeding to the only one which had any practical result; it is that of M. de Senarmont, who obtained similar microscopic crystals by exposing hydrate of alumina, or alumina combined with water, to a great heat, which caused the water to evaporate, and left the crystals at the bottom of the glass tubes in which the experiment was conducted.

The perseverance of M. Gaudin, who appears never to have abandoned the idea of manufacturing precious stones, enabled him, in 1857, to present to the Academy of Sciences several white sapphires produced by a very simple process, and of sufficient size to be used as jewels in watches.

The following is the mode of procedure by which M. Gaudin succeeded in producing these crystals :—

In a crucible lined with animal charcoal are placed equal parts of alum and sulphate of potash, previously calcined to expel the water. With this mixture the crucible is half filled; it is then filled up to the top with animal charcoal, the lid is put on and cemented in its place with clay, and it is then exposed in a furnace, and kept at a white heat for a quarter of an hour. The heat and the reducing power of the charcoal cause the formation of sulphuret of potassium, which fuses and dissolves the alumina; the continued action of the heat partly evaporates this sulphuret of potassium, and the alumina separates in the form of little crystals. On opening the crucible, a black mass, sparkling with brilliant points, is found in it, which consists of sulphuret of potassium mixed with crystals of alumina. This mass is afterwards placed in diluted nitro-hydrochloric acid, which dissolves the sulphuret, and lets fall the crystals of alumina to the bottom of the vessel, where they appear as a coarse powder, and, seen through a microscope, have an exact resemblance in form to the natural precious stones. By using a larger crucible, and exposing it to the action of the fire for a longer period, M. Gaudin produced crystals of much greater dimensions, which, upon examination, proved to be true white sapphires, and were even superior in hardness to the rubies ordinarily used for the jewelling of watches. He endeavoured to produce coloured crystals by the addition of metallic oxides, but found that these were invariably reduced into metals by the action of the charcoal. The successful result of this experiment encourages us to hope that at a future period M. Gaudin, or some one else possessed of his indomitable perseverance, may discover some substance capable of dissolving carbon in a similar manner to that in which sulphuret of potassium has been found to dissolve alumina, by which the

problem of the artificial production of that beautiful and valuable stone, the diamond, will at length be solved.

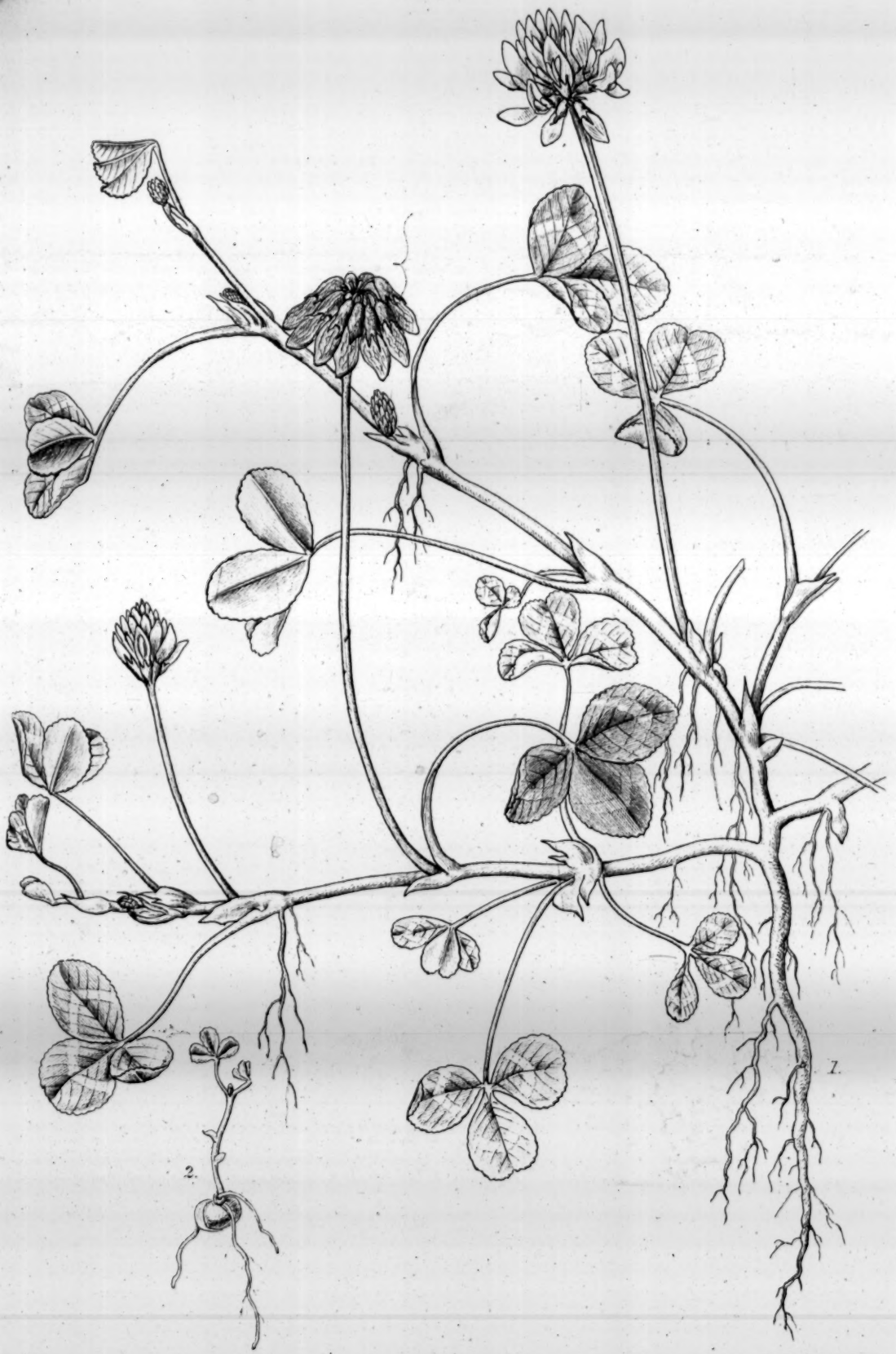
Although not belonging strictly to the subject of the artificial production of precious stones, it will not, perhaps, be thought inappropriate to notice some experiments undertaken by Messrs. Deville and Wohler, which resulted in the discovery of a crystal strongly resembling the diamond in its hardness and properties, although of a different composition. This crystal is that of a substance called boron, which attracted the attention of Messrs. Deville and Wohler on account of its resemblance to carbon. It occurred to these gentlemen that a substance having such a great similarity to the element of which the diamond is composed would, in all probability, if crystallized, have some characteristics in common with that gem. They, therefore, set to work to find some process which would enable them to reduce it to the crystalline form.

Boron is only found in nature in combination with oxygen, as boracic acid, and in union with soda as borax; and it had, up to this time, been obtained from these combinations only in the form of a brownish-green powder, insoluble in water, and possessing many of the properties of carbon. It was reserved for the two chemists whose names are given above to produce it in a form hitherto unknown, by the following process:—

In a crucible lined with animal charcoal are placed eighty grains of aluminium and one hundred grains of boracic acid; this crucible is then exposed for five hours to an intense heat, which causes a portion of the boracic acid to part with its oxygen to the aluminium. After it has been taken from the furnace and allowed to cool, it is found to contain a sort of glass composed of the remainder of the boracic acid and of the alumina formed during the process of heating, and underneath this a grey metallic mass sparkling with crystals. This mass consists merely of boron imbedded in aluminium. To separate the boron, the mass is plunged into boiling caustic soda, which dissolves the aluminium, and is afterwards treated with hydrochloric acid, to remove all traces of iron, and with a mixture of nitric and hydrofluoric acids, to get rid of any silicon that may have been left by the soda. After all these processes have been gone through, the boron remains alone.

An examination of the boron obtained in this way shows what a great analogy exists between it and carbon, which, as every one knows, is found in three forms: uncrystallized in charcoal; semi-crystallized in plumbago; and crystallized in the diamond. Similarly the boron resulting from the above experiment is found to exist in three forms, viz.: in black flakes almost as hard as the diamond; in brilliant prismatic crystals less hard than the former variety; and in small, beau-

tifully-formed reddish crystals, having a great resemblance to the diamond. These crystals are as hard as the diamond itself, and may, in course of time, should their manufacture be brought to perfection, supersede that stone in many of its uses, such as cutting and polishing precious stones, forming jewels in watches, &c.; and thus, although from their being unknown in nature they cannot be considered precious stones, the discovery of these boron diamonds may prove of more practical value than all the attempts at the artificial production of the real diamond.



T.West sc.

W.West imp.

White Clover.

ON THE WHITE CLOVER.

BY MRS. LANKESTER.

THERE is, perhaps, no natural order of plants more easily distinguished than the Leguminosæ, or Pea tribe; yet for the most part people are content to recognize the external characteristics of the different plants of this order, leaving unstudied the many interesting points of structure which are apparent in the humblest and most common representatives of the family. With the view of thoroughly examining the attributes and peculiarities of the order, so as to render them familiar to all who desire to make their acquaintance, we have chosen the most easily attainable and most abundantly common member of this interesting family as the subject of our present paper. Perhaps it cannot be positively asserted that the Dutch or White Clover is truly a native of the British Isles; but it is now so long since its introduction, that we may claim for it the privilege of naturalization, and safely reckon it amongst our British plants.

The main and universal characteristic of the order Leguminosæ is, that it consists of plants bearing pods, or legumes; and, as the order derives its name from this circumstance, it is important fully to understand the term; it is, in fact, a superior (that is, above the calyx of the flower) one-celled, one or many seeded fruit, opening on the upper side of the pod so as to form two valves. The seeds are fastened to one side only of the case alternately to each valve, by short pedicels or stalks. A pea-pod forms a very perfect example of what a legume really is, but the forms and varieties this organ may assume are numerous. It may be twisted like a screw, as in the Lucerne; coiled round like a caterpillar, as in *Scorpiurus sulcata;* curled like a snail, as in *Medicago;* or curved like a worm, as in some species of Acacia; still it is a legume, and preserves its resemblance to the pea-pod, in opening in the same manner if a little pressure be applied to the top, as in the process of shelling peas. The varying size of the legume is also another point worthy of notice. It is very minute in many of the British species of the order, as in the small clover, whilst in some tropical forms of Cassia it attains a length of two or three feet. It is worthy of remark, however, that it is always constructed on the same plan.

Then comes the singular arrangement of the petals, which, in the first subdivision of the order, *Papilionaceæ*, has been fan-

cifully likened to a butterfly. To this subdivision belongs our selected example, the Clover. The calyx of all leguminous plants is apparently composed of one entire piece ending in five distinct points, or perhaps they may be described as five sepals united together in a tube. The corolla consists of five parts or petals, one of which is larger than the rest, and stands up at the back of the others, forming a sort of covering or mantle to them before the flower expands: this is called the standard, banner, or vexillum. In front of the standard, and practically adherent to it, are two side-pieces, or *wings*, which are carefully folded over a projecting or boat-shaped part of the corolla, which comes prominently forward, and is called the *keel* or *carina*. This is formed of two petals, slightly adherent by their lower edges to each other. In this keel or cradle, as it were, lies hidden the provision which nature makes for the growth of future generations of like plants. We have thus traced the five portions of the corolla, which correspond in number to those of the calyx, but are so disguised by their curious arrangement that they might not be easily recognized.

We might almost say that the fanciful names applied to the different parts lead to confusion, for the original figure of a butterfly is curiously lost in the addition of a standard or banner at its back, and the keel or prow of a boat in front. Consistency, or regard to the real purpose of an organ, is very frequently overlooked by poetical naturalists.

The young fruit, protected by the keel or valve, is at first surrounded by a sort of membrane formed by the filaments of the stamens, which are united below, but distinct above, and surround the germ or bud of the legume. These ten filaments only appear to be united together at their base, for on close examination we find that nine only of them adhere together, and that the tenth gradually separates itself from the rest, leaving an opening by which the fruit or legume, when it is formed, can extend itself and become developed. On the top of each of these threads there is the yellow anther containing the pollen dust, which falls on the centre body or stigma which terminates the style. This style is but a sort of thread-like continuation of the legume, to which it adheres even after its work has been done in conveying the pollen dust to the ovules, and so ensuring the production of the complete legume with its perfect seeds. The nine stamens, faithful to each other, wither and die together, leaving the discarded and solitary brother as their only representative. It was on account of this separation of the ten stamens into two groups of one and nine, that Linnæus made this group of plants to constitute his class *Diadelphia*, or two brotherhoods.

Leguminous plants are divided into those which have their

stamens united and their flowers papilionaceous, and those which have their stamens *separate*. To the first belong all the most commonly recognized plants of the order, and all our British and European species.

Not the least interesting feature of this leguminous family of plants is their seeds, the peculiar construction and germination of which are worth attentive study. If we call to mind the ordinary nature of seeds, we find that they have an external covering, or testa, surrounding a mass of white pulp, or meat, as it is sometimes called, which is the substance for which seeds are usually taken as food. This white substance, known by the name of *albumen*, but which is by no means the *albumen* of the chemist, encases the little embryo plant. Chemical changes go on in the substance of this albumen, and the starch of which it is principally composed is converted into matters suitable for absorption by the young plant, such as sugar and dextrine. The seed absorbs water from the soil in which it is placed, which, swelling its substance, causes it to burst its external case, and the little embryo plant protrudes, first downwards, with its tiny radicle or root, and then upwards, with its little plumule or stem. Usually the outside case in which it was nourished, but for which it has no longer any need, remains in the ground and dies away. The seeds of leguminous plants, for the most part, differ from other seeds in the fact that they are destitute of this albumen or internal substance which surrounds the young plant. In their case the embryo fills up the whole of the seed, and has nothing intervening between it and the testa. The seed consists entirely of two *cotyledons*, or seed-leaves, which cover the embryo, and which at the time of germination separate, allowing the plumule and radicle to escape from between them. They then assume the form of leaves, and rise out of the ground with the plant itself, presenting the curious appearance we must all have noticed in sprouting peas or beans, apparently carrying up the old seed on their stems. The seeds of such plants as we are speaking of are, in truth, merely well and skilfully packed leaves or cotyledons surrounding the precious germ of future life in the plant—the promise of perpetuity in itself.

A very interesting and instructive experiment may easily be performed by soaking the seeds of any leguminous plant in water, and watching from day to day the development and growth of the young plant, and the ascension or expansion of its protecting cotyledons. In the Papilionaceous division of the order the seeds are a most important article of commerce. Under the name of Pulse they are valuable as food to animals and to man. Peas, beans, lentils, and some others, are familiar instances. The curious little ground-nut (*Arachis hypogea*), which, when

sold in the shops roasted, is pleasant enough to eat, is another instance. We find, however, that this fruit does not possess the usual characteristic of the legume, for the pod in which the seeds are inclosed breaks or splits up irregularly. In some plants of this family the seeds are undoubtedly unwholesome, if not poisonous, and great care should be taken to avoid them: such, for instance, as the common Laburnum.

The second sub-order of the *Leguminosæ* is called the *Cæsalpinieæ*, or the Senna section. It includes only foreign plants. They have imbricated petals—that is, petals which wrap over each other in the bud, the upper one being in the inside, and each petal more closely resembles its fellow than those of the *Papilionaceæ*. In some cases the petals are absent. The plants of this division are chiefly those which are useful in dyeing or for medicine—senna, logwood, and the tamarind are amongst them; and, were we attempting to write a complete history of the remarkable products of the family *Leguminosæ*, we should find in this subdivision alone enough interesting matter to fill many pages. In Dr. Lindley's "Vegetable Kingdom" there is given a drawing of one of the Great Locust trees of the West, described by Martius as belonging to this subdivision of *Leguminosæ*, which is of such enormous dimensions that fifteen Indians, with outstretched arms, could only just embrace one of them. By counting the concentric rings of such parts of the stem as were accessible, Martius concluded that some of these trees now existing were of the age of Homer; indeed, several of them were computed to have seen even remoter times. It seems almost incredible that the modest little plant which we have taken as the representative of this great family should claim kindred with these mighty forest trees, and become the easiest exponent of their distinguishing characteristics.

The third subdivision of the order is called *Mimoseæ*, or the Gum-Arabic section. It consists chiefly of plants in which gummy and astringent matters prevail. The petals are regular and valvate in æstivation,—that is, they do not overlap in the bud. Various species of Acacia belong to this section. *Acacia formosa* supplies the valuable Cuba timber called Sabicu, of which was made the stairs of the Crystal Palace in Hyde Park in 1851. The astringent substance known as *Catechu* is furnished by several species of Acacia. The Rosewood of commerce, so well recorded in our domestic articles of furniture, is produced by a species of *Mimosa* from the forests of Brazil. A species of *Mimosa* is an object of interest in our conservatories and greenhouses on account of its sensitive properties. There are but few of us who have not been amused with watching the closing, shrinking leaves of *Mimosa sensitiva*, when touched or handled.

This very slight sketch of the nature and products of this great natural family will be sufficient to show how very important a section of the vegetable kingdom it is. In our own country, the representatives of the order are chiefly confined to small herbaceous plants; they all retain the characteristic papilionaceous flowers and diadelphous stamens, and are perhaps not less valuable for their properties than their more showy and striking relatives—the inhabitants of warmer climes. To whatever magnificence these may attain, or under whatever form they are recognized, we find that they still possess one or other of the family features: in many cases the papilionaceous flowers have disappeared, but the leguminous fruit remains; or it may be that the flower still retains its butterfly shape, and the form of the fruit is changed.

But to return to our text—the Papilionaceous division of the order. The Liquorice of commerce, *Glycyrrhiza glabra;* the Indigo, produced from various species of *Indigofera;* the Locust-tree, which yields such beautiful timber; the graceful Laburnum, with its lovely golden drooping flowers; the charming Wisteria; and the unpleasant substance known as Cowitch, which is the sharp hair of the pods or legumes of a species of *Mucuna,* and many other interesting plants, all claim kindred under the name *Papilionaceæ,* being separated only by generic distinctions. Our modest little friend, the White or Dutch Clover, belongs to this subdivision, and is referred to the genus *Trifolium.*

This genus is one of the most extensive in the vegetable kingdom. It is known by the flowers being collected together in heads. The calyx is tubular, five-parted; the corolla is papilionaceous, consisting of the five petals which remain after decay; the stamens are diadelphous, more or less closely attached to the petals; the legume ovate, with one, two, or sometimes three or four seeds. All the species are herbaceous, and are included under the general name Clover, which includes some of our most important agricultural products. They are annual, biennial, or perennial plants, and are distinguished by the triple or three-parted leaf; from which they derive their name Trefle, or Trefoil. There are above twenty species natives of Great Britain, more or less valuable as fodder, and some of them are considered as indispensable to the farmer in the improved system of farming by a rotation of crops. The species chiefly cultivated are the Purple Clover (*T. pratense*); Cowgrass, or Perennial Clover (*T. pratense perenne*); Alsike Clover (*T. hybridum*); Zigzag Clover (*T. medium*); Scarlet Clover (*T. incarnatum*); Hop Trefoil (*T. procumbens*); and the White or Dutch clover (*T. repens*).

This latter species is the one about which we are at present

chiefly interested. It grows rapidly and forms excellent pasture, but its bulk is not sufficient to make it profitable to mow it for hay. Sheep thrive well upon it, and there are but few meadows or moors where it is not to be found. So common is this little plant in almost every plot of ground in our country, that it is as familiar to us as any other wild plant. The more pretentious, larger, and showy species of clover, do not appear except under cultivation, and seem to owe their existence more to the agency and care of man than does our modest little friend, the White Clover. Withering says, "On the soil of our moors in the north of England being turned up for the first time and lime applied, white clover appears in abundance; a circumstance in no way satisfactorily accounted for, but which is known to take place in wastes both in Britain and North America." In such situations the seed may have lain dormant for a length of time, until stimulated into vegetation by the admission of moisture and heat.

The common plants of a country are almost universally associated with its legends and poetry. The Irish names for the *Trifolium repens* are Shamrock—Shamrog, or Seamur-oge; and some botanists claim for it priority as the national emblem of Ireland. Many and warm have been the disputes to determine which of the three-leaved plants is the veritable shamrock. Some contend for the *Oxalis Acetosella*—wood-sorrel; while others maintain that the white clover is the favoured plant of St. Patrick, who, when preaching the Gospel in earliest times to the benighted inhabitants of the Emerald Isle, chose to illustrate the great doctrine of the Trinity by the simple instance of a triune nature in this well-known and beautiful leaf. Whether he plucked for the purpose the bright-green leaf of the wood-sorrel, or the familiar herbage of the white clover, cannot now be well ascertained. We are inclined to think that the national symbol is equally preserved in either plant; and in Ireland at this day, the trifolium is necessarily more frequently adopted than the oxalis by those who keep up national customs.

It would seem to be the tendency of nations to dedicate to their patron saint some plant with which they are familiar at that season of the year when the feast in his honour is celebrated. Thus, the Welsh have given the leek to St. David, as almost the only green thing to be found in Wales on St. David's Day. The Scotch have adopted the thistle for St. Andrew, whose celebration falls in the autumn, when thistles are abundant. Our own champion, St. George, seems by his warlike temperament to have discouraged anything like the sentimental dedication of a flower to his memory. This idea rather discountenances the notion that *Trifolium repens* is the veritable

trefoil of Ireland, for it does not arrive at perfection until considerably after the 17th of March, or St. Patrick's Day. The term Shamrock seems to be a general application for all trefoils or three-leaved plants, both in ancient and modern poetry and prose. Piers, in speaking of the early spring-time in Ireland, says, "For then the milk becomes plenty, and butter and new cheese, and curds and shamrocks, are the food of the meaner sort all this season:" and Wither, in his "Abuses Stript and Whipt," written in 1613, says:—

> "And for my cloathing in a mantle goe
> And feed on shamroots as the Irish doe."

This notion of using the shamrock as food renders it more probable that the oxalis was meant than the clover, although either might have been devoured by the starving peasantry so graphically described by Spenser, in his "View of the State of Ireland." He says:—

> "Out of every corner of the woods and glynnes they come creeping forth upon their hands, for their legs could not bear them; they looked like anatomies of death, they spoke like ghosts crying out of their graves, they did eat the dead carrions, and if they found a plot of watercresses or *shamrocks*, there they flocked as to a feast."

An Irish friend of ours who sticks to the oxalis, which is a lover of woods and shady places, as the veritable shamrock, quotes the "Irish Hudibras" against our Trifolium:—

> "Within a wood near to this place
> There grows a bunch of three-leaved grass
> Called by the boglanders, 'sham rogues,'
> A present for the queen of shoges (spirits)."

However, Irishmen now-a-days are for the most part content to mount a sprig of clover on St. Patrick's Day, for the cultivation which has brought in the more useful plant has in a great measure driven out the more poetical oxalis.

In all ages there has been a sort of mystic reverence surrounding the notion of a Trinity, and this idea seems embodied by the imaginative and poetical Irish in the triple leaflet. Whenever this sacred leaf is found to depart from its usual form, and to produce four leaflets, its mystic power is said to be greatly enhanced, and the fortunate finder of the leaf is sure of good fortune for life. Its power in dispelling illusions will account for the story of the maiden who, on returning from milking, saw the fairies dancing gaily on every rising ground, though her companions could discern nothing, and would not believe her until it was discovered that accidentally a four-leaved trefoil had got into her shoe, and had overcome the "illusion or defect of sight," which prevents ordinary mortals from seeing

the fairy beings by which they are always surrounded. In course of time the finding of the "four-leaved shamrock" was supposed to be the omen of a speedy and happy marriage (the imaginary ultimatum of bliss) to the youth or maiden who discovered it, and it became the custom to search for it after every harvest-home feast. The old song, "I'll seek a four-leaved shamrock in all the fairy dells," tells of the enchantments to be woven with the mystic leaves. The national dances of the Scotch, Welsh, and Irish, assuming with greater or less variation the nature of a reel and the described figure of eight, have their origin in the quatre-foil or four-leaved figure, which is woven by the dancers, and is associated with ancient superstitions.

With the garniture of all these poetical and historical associations, our little specimen tuft of White Clover seems to assume vastly more interesting and pleasing relations than when regarded merely as a sort of pasture grass, or as food for cattle. Important as are its useful qualities, we are insensibly more attracted to examine its minute and beautiful structure, when we call to mind all the bits of fancy surrounding its modest leaves; and we stoop to gather a handful of its simple white blossoms, or triple leaves, with something of a poetical sentiment within us. When we have examined its parts carefully and minutely with a botanical object in view, it is possible we may feel that the real poetry of nature lies deeper than is revealed to the more careless observer, and, like most things that are worth having in life, must be sought for to be enjoyed. In the dark gloomy month of December, in the midst of London fogs and frosty nights, one might well despair of finding anything like a botanical specimen; yet under such hopeless circumstances have we discovered the little *Trifolium repens* patiently nestling in a suburban garden until the warm days of spring should beam forth to invigorate and strengthen its tiny leaves, and develop the little white blossoms which are there in unseen preparation. In April or May we find it in full perfection; and throughout the summer it shares with the daisy the spontaneous duty of carpeting our meadows, downs, and uncultivated lands, at the same time well rewarding the care and skill of the farmer who encourages it to establish itself in his pastures.

The creeping underground stems of the Dutch clover favour its spreading and rapidly-increasing tendency; and, in digging up a specimen, we find that we have to remove several little rootlets, which are connected together by this creeping stem. It would appear, that when the first little plant is formed from the tiny seed it throws out this stem, which, after pressing on for an inch or so, sends up a little bud which soon expands into a perfect plant, having delicate rootlets like its predecessor;

this gives out another portion of stem, which ends in another little plant, and so on, till in a very short time a large space of ground is covered with its pretty green leaves and white flowers. When not in flower the *Trifolium repens* may be somewhat difficult to recognize, as its triple leaves are but slightly different from other species of the same genus. We will suppose that, tired with a country walk in the middle of a warm day in April, we have thrown ourselves down on a green bank, or a tempting sunny spot on some richly "carpeted and sheep" trodden down. Our eyes naturally seek the couch on which we rest, and almost certainly, in whatever locality we may be, we shall see all around us the tiny three-parted leaves of Trifolium conspicuous amongst the other herbage, which makes the natural beauty of our lanes so great. In two square inches of turf on which we were dreamily resting one warm day, last July, we counted eight different species of plants—all so closely matted and packed together that, without the temptation of having nothing else to do, we should scarcely have examined closely enough to distinguish them. With a botanical pocket-glass in our hand we carefully looked at each little verdant tuft in the measured space, and there sure enough was the never-failing little Dutch clover (*Trifolium repens*), the Bird's-foot Trefoil (*Lotus corniculatus*), Gold-dust (*Galium verum*), the Common Cranesbill (*Erodium cicutarium*), with several species of grass. By our side sat a friend whose thoughts seemed never to have descended so low before, and great was his surprise when this variety of vegetation in so small a space was pointed out to him. Having a botanical tendency ourselves, we were provided with a little tin vasculum, or sandwich-case, into which we placed the two square inches of turf for closer examination at home. A bright luxuriant plant of white clover suggested its suitability for a lesson in botany to our unscientific friend; accordingly it was ruthlessly pulled up by the roots, bringing with it other plants of its own kind attached to the creeping stems—some just forming, others in perfection. Those who are in earnest to know something of botany—something of the great vegetable world by which we are surrounded—cannot do better than follow our example. In choosing one simple little plant as a representative of any of the great families of plants, they will soon find that they are led on imperceptibly to a full acquaintance with the greater and more complicated discoveries of science.

We will imagine, therefore, that we have our tufts of *Trifolium repens* before us (plate xix.). If we wish preserve it fresh for some days, and to examine at our leisure all its parts, put it into a saucer with a little moisture and cover it with a hand-glass. Here, then, is the pretty white or whitish head of

flowers. Each little tiny flower growing in the round white head is a perfect type of the order to which it belongs, and possesses all the characteristics which we have described in the Leguminosæ. There is the tiny calyx, with ten little markings or ribs on its surface, and cut into five small teeth at the top, two of which are longer than the others. This contains the corolla, with its curiously-shaped parts; the two side petals or wings, the protruded keel in front, and the standard or erect petal at the back (fig. 3). This is sometimes marked and striped with a pinkish colour. The keel incloses the ten stamens (fig. 4), nine together and one alone; and the style, which becomes in time the legume, or the pod (fig. 5), containing the little seeds (fig. 6). Very frequently we may notice as the season advances that the white heads of the clover are fringed round with dead or withered flowers, which lose their upright position and hang down level with the stalk. These are the flowers which have performed their function: they have matured the provision for future life within themselves, and contain the tiny pod, with its two or three seeds which will perpetuate their species. Contrary to the general law in plants, the petals do not fall off when they wither and the fruit is formed, but remain persistently on the flower-stalk and calyx until the whole plant perishes. The outer row of flowers, coming first to perfection, fall downwards and form this brown fringe-like appearance round the head.

Having carefully examined every part of the flowers, let us take a leaf with its thin delicate stalk, and observe the beautiful markings on its surface, and the crescent-shaped figure which is impressed towards its base—sometimes hardly perceptible, at others of a darkish purplish colour, and very distinct. This coloured marking of the leaf sometimes extends over its whole surface, and clover leaves are often found in which the green colouring matter, or chlorophyle, has entirely assumed a purple hue. This change suggests to us that it is by no means essential to the nature of a leaf that it should be green. In the varied and beautiful tints of autumn, who has not been struck with the almost gorgeous colours of leaves? Bright red, brilliant orange, and deep purple, vie with each other to compensate to the eye for the absence of summer flowers. And in these very flowers, whose coloured petals at first sight seem altogether different from the surrounding leaves, we may shortly be able to trace evidences of identity with the green forest around them.

Let us now place one of the three little leaflets under the microscope. The markings are very distinct, and the edges of the leaf which appear so even and smooth to the naked eye are seen to be surrounded with points, towards each of which a

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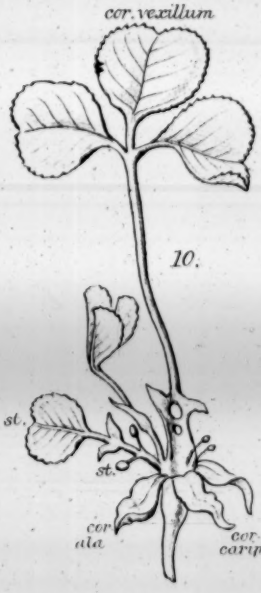

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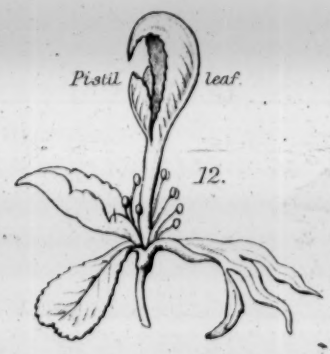

12.

T.West. sc.

W.West. imp.

Morphology of White Clover.

vein or rib is directed, and in an angle from which another vein proceeds. The little stomates, or breathing-pores as they have been called, are seen very evidently in this leaf; but as these interesting organs have been fully described as they occur in the Daisy,* we will not go into their history here. The microscope shows us that the ribs of the leaves are composed of woody fibre and spiral tissue, and in making a section of the stalk of the leaf the bundles of this beautiful spiral tissue are very abundant. No object can be more attractive than this very delicate and beautiful material; it seems to abound chiefly in the stems of plants, as if nature had provided this elastic contrivance as a precaution against the rough blasts and storms, which would prove destructive to a less pliant and yielding tissue, and rudely snap asunder the support of the unprotected leaves and flowers. In our specimen we shall find flowers containing the little pods and seeds, which latter are interesting on examining them in their various stages of development. When first formed they consist, as in all other leguminous plants, principally of the young embroyo. As this little embryo grows and develops it lives upon the food provided for it in its cotyledous or seed-leaves, and if we place the tiny seed in circumstances favourable for germination, we shall soon discover the living nature of its inhabitant. When kept dry the process of development does not go on in the seed; but if we place a few little seeds in moisture, or in some earth under a glass shade, we can then watch the growth of the young plant, and its liberation from its encasement. Just before the bursting of the seed, if we submit it to the microscope, we find that a great portion of the starch and sugar which distend the seed-leaves in an earlier stage have disappeared, and the various tissues can be observed which are to form the young plant. We can distinctly trace the imperfect spiral fibre and woody tissue; and now the form of the little embryo is evident. At each end is a little tail-like appendage, which, pressing against the external seed-case, causes it to burst open, and from it is sent downwards the radicle or future root, and upwards the little greenish-white plumule. In common with the rest of its order, this tiny sprout bears upwards with it the cotyledons and the forsaken seed-case, which remains attached to them during their short life. (fig. 2). All life seems to be but the preparation for a higher existence. The seed-leaves wither and give place to the stem-leaves, and these become perfected in the budding flower, which in all its beauty is but the temporary abode of those organs which have for their object the perpetuation of the species.

* See Popular Science Review, No. 1.

In studying plant life, the fact is often forcibly presented to us that while all the designs of Nature seem to refer rather to the future than the present, yet each stage and phase of life is perfect in itself, and is none the less lovely or apparently content with its existence because it is transient and preparative for another set of organs tending to accomplish the higher ends of existence.

No class of plants affords such evident and interesting examples of the law of morphology in vegetables as do the *Leguminosæ*. In the white clover we frequently meet with cases in which parts of the flower exhibit a tendency to return to their leafy origin: the pod frequently changes into a small leaf, whilst the stamens, petals, and sepals all exhibit the same tendency, the pedicels of the flowers at the same time elongating. We have seen many specimens where the whole head of flowers on a stalk of clover has undergone this transformation, presenting the most singular appearance possible, with the green leaves looking as if quite out of their accustomed place, and, consequently, very odd and uncomfortable. In passing through a field of clover it is worth while to look for such monstrosities, and they are by no means uncommon.

We are indebted to the pencil of a lady (Mrs. Godwin-Austen) for a series of beautiful illustrations of the changes undergone by the flowers of the White Clover in their most sportive moods. (figs. 8, 9, 10, 11, 12). These were exhibited at the Meeting of the British Association, at Birmingham, in 1849, and were afterwards published in *Henfrey's Botanical Gazette* for March, 1850. Through her kindness we are enabled to give a sketch of some of the more interesting forms which these flowers assume.

It was a happy idea of the great German poet-botanist to reduce the previously received and complicated theory of plant structure to the simple formula of leaf formation. In this way everything presented itself to him under a different aspect:—what had been considered essential became accidental, and *vice versâ*. In all the higher plants, foliage, flowers, and fruit were regarded as essentially different parts. It was Göethe who first recognized in the flower and fruit the recurrence of the foliage, so that there is no essential difference between these three parts of a plant. In studying this subject somewhat carefully, it becomes evident that it is the leaf which, in its Protean capability of transformation, gradually assumes the form of fruit or flower. These are truly leaves,—whorls of leaves differing in character and position from other leaves, although not in their essential nature. This great doctrine of unity of plan in creation was first demonstrated and successfully taught in relation to the vegetable kingdom, and has since

been clearly worked out and adopted by the ablest comparative anatomists of this and other countries as applied to higher organisms, and even to man himself.

The susceptibility of the little *Trifolium* to the withdrawal of light, and its habit of closing its leaves somewhat on the approach of night, remind us of its family relationship to the group of Sensitive plants. While examining the tissue of the stems under the microscope, the abundance of spiral fibre suggested the thought that this very elastic and delicate material might possibly have something to do with the hitherto unexplained cause of the curious movements of the Sensitive Plants. Microscopic research, in skilful hands, will do much to clear up these unsolved questions; yet we cannot hope to see the time when, in the whole Ocean of Truth, there shall not be, even to the greatest and wisest of our race, hidden and unexplored depths, whose existence is only indicated on the surface by a gentle ripple, which excites no attention from the casual observer. Let us, each in his own way, be it ever so small, do what we can to trace out and mark

"Lessons of wisdom even in a flower."

DESCRIPTION OF PLATES XIX. AND XX.

Fig. 1. Plant of White Clover.
2. Seed of White Clover germinating.
3. Flower of White Clover.
4. Stamens of same.
5. Legume or Fruit.
6, 7. Seed.
8. Metamorphosis of the calyx teeth of the flower into leaves.
9. The Flowerets, consisting of a calyx larger than usual, with mere rudimentary traces of petals and stamens, and the plant passing over two stages of its flower structure proceeds directly to form a pod.
10. A specimen in which the stamens were distinct, but where one stamen had the form of a leaf, with two bract-like appendages, perhaps representing two other leaves at its base, together with a true stamen attached to the stalk at either side.
11. The Pistil metamorphosed into a perfect expanded leaf, leaflets occupying the place of ovules at its edge.
12. The Pistil represented by a leaflet which is metamorphosed into a pod, two abortive leaflets at the base of the imperfect pod on either side.

THE HUMAN HEART.

BY ISAAC ASHE, B.A., T.C.D., L.M.

THE ingenuity and yet simplicity of contrivance which the Creator so abundantly displays in every department of nature is, perhaps, nowhere so highly manifested as when He designs to provide for the existence and enjoyment of a sentient and conscious being; and doubtless it is to be anticipated, that as His creatures rise in the scale of conscious beings, so much the more abundant care would be bestowed in ensuring the welfare of their more highly endowed and more exquisitely sensitive frames. Accordingly, we have in Man the head of the terrestrial creation, the greatest amount and the most exquisite adaptation of contrivance, the highest evidence of design, and not only so, but of the beneficence and goodness of the Designer, and of His intention to render the human body in every respect a suitable and pleasant abode for the rational spirit destined for a time to inhabit it.

Hence, although there must always exist a considerable repugnance at first to the investigation of the structure of the body, yet, when this is overcome by the force of habit and professional duty, the beauties which are revealed in that structure are such as to fill with delight the thinking and intelligent mind which finds pleasure in witnessing the exquisite adaptation of means to the end which is to be accomplished.

The organ whose structure we have selected as the subject of the present sketch is the heart,—one which has always struck us as a masterpiece of ingenious design, perhaps, not to be exceeded by any part of the body, even the eye or ear, and one whose beauties are less generally known than those of either of these organs.

The heart, then, as all our readers know, is the principal means by which the vital fluid, the blood, is sent to every part of the body by a process of pumping quite analogous to what is seen in an ordinary forcing pump, though of much more delicate and perfect construction; indeed, it seems highly probable that the principle of the forcing pump was borrowed from this organ.

Now, what are the objects which have to be accomplished in this circulation of the blood, and how is the heart adapted to

their attainment; and what are the contrivances for the avoidance of those dangers which would, mechanically, be most likely to occur?

First of all, a supply of nourishment has to be furnished to every part of the body, no structure or organ being omitted; secondly, waste material has to be taken up and removed from the system after it has served its purposes there; and both these objects are accomplished by the circulating vital fluid, the first by a transudation of the watery part of the blood through the pores of the walls of those minute capillaries which ramify through every portion of the body, and which are too minute to permit the red corpuscles of the blood to escape, the function of these latter apparently being to vivify the watery portion or serum of the blood, which is the nutrient fluid: while the second of the objects above mentioned is attained by the blood circulating through various organs in the body, whose special function it is to remove used up material by peculiar vital processes, of which nothing farther is known than this, that they are effected by the same transudation of serum through the walls of the capillaries, or, in the case of the lungs, with which we are at present most concerned, by a similar passage of carbonic acid and water out through the walls of the air-cells of which the lungs are composed, while oxygen at the same time passes in by a similar process.

Through the other secreting and excreting organs, the blood, or a portion at least of it, passes in the course of the general circulation of the body, but through the lungs the whole of it passes by a separate circulation quite distinct from that of the body, and called the pulmonic circulation. Since the heart, then, has to effect two distinct circulations, it is necessary that it should be in effect double; and such is, in fact, the case, so that physiologically there are two quite distinct hearts in man and the higher animals, although anatomically the two are joined together. There are, therefore, four chambers, two for receiving the blood, the first on its return from the body, the second on its return from the lungs; these are called "auricles;" and two for expelling the blood through the circulation, the first through the pulmonic circulation, and the second through the systemic circulation, or that of the body; these chambers are called "ventricles." In the heart of fishes there are but two chambers, one auricle and one ventricle; in Batrachia, there are three chambers, two auricles and a ventricle; while in reptiles the ventricle has a partition which is imperfect in the lower classes, so that their heart has virtually only three cavities, but which becomes perfect in the Crocodiles, so that theirs, like that of birds and mammalia, is composed of four cavities.

This four-chambered heart is a muscle, and acts by means of muscular force. What the agent may be which irritates this muscle and so causes it to contract, has been a subject of much discussion; but it is now generally considered that this agent is oxygen, which is received into the blood in the lungs, and stimulates the muscular contractility of the heart through the nerves of the organ. This muscular action of the heart is almost entirely beyond the control of the will, as indeed are all the vital actions of the body; yet instances have been related of persons who were able to stop the heart's action at will, and in one case this experiment was carried too far, and the individual died by the mere act of his own will. On the other hand, the heart will continue its regular pulsations for a long time after its removal from the body, and of course the death of the animal; and the lower the creature in the scale of creation, the longer will this action continue; so that the heart of a sturgeon will continue to beat as long as twenty-four hours after its removal from the creature.

Through this four-chambered heart, then, the blood must pass in one direction only, and not indiscriminately backwards or forwards; and to effect this there is a whole series of beautiful contrivances. To begin with the first chamber, namely, the right auricle. As this chamber is dilating after each contraction it receives the blood which has been collected from all parts of the body into two enormous veins, and it also receives blood from some small veins which come from the substance of the heart itself,—for this organ has of course to supply blood to nourish its own muscular substance; but some force is wanting besides the mere dilatation of the auricle in order to ensure its being properly filled with blood, especially in the case of the vein, which, coming from the lower parts of the body, has to send its blood against the force of gravity, and accordingly these two large veins are provided with muscular coats for a short distance back from the auricle. There is a large opening between this auricle and the second chamber, namely, the right ventricle, an opening large enough to admit the tops of three fingers, and some of the blood flows through this opening at once, but the greater part of it fills the auricle which will contain about two ounces. It fills slowly, but the moment it is full it makes an extremely quick contraction, by which it forces nearly the whole of the blood through the opening into the right ventricle. Quick as this contraction is, occupying about the eighth part of a second, it can be observed to begin where the great veins enter the auricle, and to extend gradually over to the opening into the ventricle; and this is just what is necessary to ensure the driving of the blood gradually from behind forwards into the ventricle, and the blood cannot return up

the veins because the muscular contraction of their coats prevents it, in addition to which there is a most beautiful set of valves in the inside of the veins which only open towards the heart, so that the blood can pass that way, but not backwards. In the smaller veins of the body a pair of these valves can be seen at about every quarter inch, but they do not exist in the very small veins, nor in the great vein which comes into the right auricle from above; for, under ordinary circumstances, the blood is prevented from flowing backwards in this by the force of gravity, and under extraordinary circumstances it is sometimes necessary that it should flow back through it, as will be explained shortly. The walls of the auricle are very smooth, so as to allow the blood to pass freely along them, and they are not very strong, as they only have to force the blood into the next chamber, which is gradually opening to receive it. As soon as this chamber, the right ventricle, is full, it also contracts, but much more slowly than the auricle, since it has to overcome much greater resistance, for it has to force the blood along the pulmonary artery, and through all the capillary vessels of the air-cells of the lungs. And to effect this, its walls are very strong, and furnished with several muscular bands inside, which contract at the same time that the walls are contracting, and so both help the wall, as it were, and also by becoming thicker in consequence of their shortening, fill up the whole cavity of the ventricle, so that it completely empties itself of blood, which the auricle scarcely does.

There are, however, none of these muscular bands just at the mouth of the artery, lest they should cause obstruction to the free passage of the blood. But why does not the contraction of the ventricle force back the blood into the auricle which is just then dilating again? Because, inside the ventricle, and over the opening between the two chambers, there are three thin membranous valves which only open into the ventricle, but the moment the blood is driven against them by the ventricle beginning to contract, they are closed by its impetus, and, fitting accurately, completely prevent all regurgitation into the auricle.

The bases of these valves are connected with the opening all round, and their sides are partially connected with each other, so as to close the opening completely. But there would be considerable danger that the great force with which the ventricle contracts would drive the tips of these valves, which are in the centre when they close the opening, completely through into the auricle, and so allow regurgitation to take place notwithstanding, and the whole machinery to become hopelessly disorganised. To prevent this terrible accident, which would cause instant death, there are a large number of very fine but very strong branching tendons attached all over these valves on the

side next the ventricle, but principally along their margins, where there is the greatest danger of their being forced through, and the other ends of these tendons are united to the ends of muscular bands like those which help the contraction of the ventricle, the other ends of these bands being fastened to the wall of the ventricle,—so that they actually hold the valves like ropes, and so prevent them going through into the auricle: of course, these ropes, so to call them, must shorten as the ventricle contracts, and its wall comes near the opening, since otherwise they would not be tight, and would consequently be useless, and this is accomplished by the muscular bands contracting at the same instant with the ventricle itself, so that the tendinous threads are always kept tight, and the muscular bands relax themselves, and consequently lengthen, as the ventricle dilates, for, otherwise, they would tear the valves completely off their attachments. Thus we see the advantage of having these checks on the valves composed partly of tendon, which will not shorten nor lengthen, and partly of muscle, which will do so; for if they were all of tendon they would not contract nor remain tight, and the valves would be forced through, and if they were altogether of muscle the contraction would be too great, and would draw the valves inwards, so that they could not completely close, and the blood would regurgitate.

There is, however, another very beautiful arrangement here to prevent the blood being forced in too great quantity into the delicate vessels of the lungs during violent exertion, as this would rupture them,—a result which sometimes takes place in spite of the contrivance to avoid it, and hence we sometimes see runners and others spit blood after violent exertion.

This contrivance consists in having one of the muscular bands mentioned above very long, but placed nearly opposite the valves, so that though there is very little tendon attached to it, yet during a contraction of the ventricle the other end is brought so close to the valves that it does not draw them inwards nor prevent their complete closure; but if the ventricle should ever become too full, so as to endanger the lungs, then the other end of this muscle, being attached just opposite the valves, is drawn away a long distance from them, so that when this muscular band contracts it does draw the valves inwards, and allows the blood to regurgitate into the auricle, and from it into the great vein which comes from the upper part of the body, and so the pressure is taken off the lungs. Hence it is that the veins of the neck and face become distended during exertion; and the same thing is seen to take place during a prolonged note in singing, for then the blood does not pass so freely through the lungs, and this safety-valve action, as it is called, is brought into play. It was to this we referred when

we said above, that, under extraordinary circumstances, valves in the upper great vein would not only be useless, but even injurious, since it was necessary that regurgitation should occasionally take place.

The right ventricle then, as it contracts, forces the blood into the pulmonary artery, a large vessel which soon divides into two branches, one going to each lung. This vessel, like all other large arteries, has elastic walls, which yield under the impulse of the blood from the heart, and immediately afterwards contract again, as all elastic tubes would do after dilating; and thus they, as it were, store up the force of the heart's contraction, and transmit it along the whole length of the vessel for the purpose of forcing the blood on throughout. In addition to this, their yielding prevents their being torn by the force with which the blood is impelled into them by each contraction of the ventricle. Here, again, we have a beautiful arrangement to prevent the blood going back into the ventricle under the force with which the elastic artery contracts again. Three semicircular or semilunar folds of membrane, strengthened by fibrous structure, form valves, which are attached by their semicircular edges to the walls of the artery, while their straight edges look towards the centre. They are so loosely attached that they can be pouched out by the blood when driven back against them, and so driven out from the sides of the artery against which they otherwise lie, and be made to stop the opening. But it would be impossible to have muscular bands and tendinous cords inside the artery to hold these valves from going through into the ventricle, for such an arrangement would hinder the blood flowing freely along the artery, and accordingly we have other contrivances to prevent such an accident in this case. In the first place, from the shape of the valves, and their being attached by so much of their margin to the artery, there is less liability to the occurrence of such an accident; and, secondly, as the fleshy mass of the contracted ventricle lies close up under these valves, it gives them support for an instant, until the blood has passed on, and the artery just beyond the valves is once more empty. Since these valves, however, lie so close along the walls of the artery, and are attached by so large a margin to it, another danger is thus incurred,—namely, that the blood which has to shut these valves should altogether fail to get between them and the walls of the artery, and so should keep them open instead of shutting them. This danger is avoided by the elasticity of the artery, for, as the vessel dilates under the shock of the blood, it is evident that it will form pouches behind the valves, into which the blood must flow, and so act on them just as the water in a canal does on the gates of a lock, which it can never shut so long as they lie flat against the

banks, but shuts immediately if they are pushed out from the banks. Just in the middle of the unattached portion of the margin of each valve there is a little projecting fibrous particle which has been considered to be useful in effecting the same object, for, as it will touch the wall of the artery first when the valve opens back, it is evident that it will keep the rest of the valve out a little from the artery, and so always leave a passage behind it for the blood. These three little particles also, one on each valve, have been considered to be of use in another way when the valves are shut; namely, by filling up the very centre of the opening, which might otherwise not be completely closed, although the margins elsewhere overlap a good deal.

As the blood comes back from the lungs after being oxygenated, it is poured by four veins into the left auricle of the heart, which is the third chamber; and this, just like the right auricle, pumps it into the left ventricle through an opening a little smaller than that on the right side of the heart, and guarded similarly by a valve having only two leaves or flaps, instead of three, but provided with the same arrangement of cords and muscles, only that here there is no safety-valve arrangement as on the right side,—since, in the first place, the left ventricle may always, and can always, empty itself of the blood as fast as it is filled with it, for it drives the blood through the body, the structure of whose capillaries is much stronger than in the capillaries of the lungs, and consequently in no danger of giving way; and, secondly, if there were a safety-valve action, it would only overload the lungs, for there are no valves in the pulmonary veins to prevent it going back as there are in other veins; and thus the very mischief would be produced, to avoid which the safety-valve arrangement is provided on the right side of the heart.

The left ventricle, or fourth chamber of the heart, is the strongest of all, since it has to drive the blood through the whole body, and it also drives a small quantity through the muscular substance of the heart itself. The great artery through which it sends the blood is called the aorta; it afterwards gives off branches, which again ramify until the subdivisions become innumerable and supply all parts of the body. Its opening is closed by three semilunar valves precisely similar to those closing the opening into the pulmonary artery; and as both these large arteries proceed upwards from the heart, the force of gravity aids the blood in shutting the valves. Sometimes, however, any of these valves may become diseased, and not act perfectly, and then death is sure to ensue shortly, and may be very sudden. We remember having a patient under our care, who suffered much, and died suddenly thus; and we found, afterwards, that every one of the three valves which

guarded the aortic opening had a large hole through the middle of it.

The muscular fibres, of which the substance of the heart is composed, and by the contractions of which its force is exerted, are very much interlaced, but the greater number of them are inserted, by both ends, into strong rings, of fibrous and cartilaginous structure, which constitute the margins of the openings from the auricles to the ventricles, and also from the ventricles to the two great arteries. The fibres which pass round the cavity of an auricle, and so form its body, are inserted by both ends into the cartilaginous ring which is between this auricle and its corresponding ventricle, and those which similarly form the corresponding ventricle are inserted into the same ring, just as in a balloon the cords which surround the balloon and those which come from the car are inserted into one and the same ring placed between the two. Some of the fibres of the ventricles are also inserted into the rings at the openings into the two great arteries, so are the arteries themselves, as well as all the valves above mentioned. In some of the larger animals, as the ox and the elephant, there is even bony structure connected with some of these rings. There are other muscular fibres which are circular, their ends being, if we may so speak, inserted into themselves, like the horizontal cords on a balloon; but to enter further on the arrangement of these fibres would be too technical for our present article.

Now, it is evident that, owing to all the motion involved in these contractions and dilatations of the heart,—motion to such an extent as even to make its pulsations visible externally between the ribs,—there would be a great amount of wear and tear, and friction against other organs, and so impediment to the heart's motion itself, and injury to it and other organs, if there were not some contrivance to obviate this result. Accordingly we have the heart completely enclosed within a beautiful bag, inside which it can work freely, without any inconvenience or danger to itself or the neighbouring organs. The structure of this bag, or closed sac, is admirably adapted for allowing freedom of motion. It consists of two membranes, which adhere closely to each other for a great part of their extent. The outer membrane is the strongest, and is continuous everywhere all round the heart, except where it is pierced by the lower great vein from the body; it forms a kind of sheath for all the other large vessels, till, at a short distance from the heart, it becomes lost on their coats. The inner membrane is very smooth and glistening, and after lining the greater part of the outer one, it leaves it near the great vessels, and attaches itself to the coats of these, and accompanies them for about two inches till they enter the heart, when it attaches itself closely to the outside of that organ,

being firmly adherent to it in every part, and completely continuous with itself; so that between the part which lines the outside of the heart and the part which lines the inside of the outer membrane, there is an empty cavity completely closed in, in which the heart moves about; and, to facilitate its movements still more, a small amount of oily fluid is secreted in the interior of this cavity by the shining walls of the inner, or serous, membrane. The arrangement of these membranes, which form what is called the pericardium, is a little difficult to explain without an illustration, and we well remember what difficulty we ourselves at first had in understanding it; but we may illustrate it by comparing the heart to a hand, with a glove fitting very closely, or rather adhering to it, thrust inside another glove fitting very loosely, the wrists of the two gloves being then sewn together, so as to form between the two a closed sac for the hand to move about in; and if we could then imagine a third glove made to adhere closely over the greater part of the second, but leaving it at the wrist, and, a little higher up, by some strange process losing itself by uniting with the skin of the arm, which in this case would represent the great vessels, the analogy would be complete.

There is yet another thin and smooth membrane which lines the inside of all the cavities of the heart; it is called the endocardium, and is continuous with itself and with the membrane lining the inside of the great vessels which enter the heart; and it is of this membrane, doubled on itself at the rings of fibrous and cartilaginous structure, and there enclosing some fibrous structure, that all the valves above alluded to are composed.

Strange to say, a wound of the muscular structure of the heart is not necessarily fatal, even though it enter the cavities, provided the valves and vessels are uninjured; the contraction of the muscular fibres is in so many different planes, that it may even close the wound and prevent bleeding. Thus there is an instance well known amongst members of the medical profession in which a soldier was shot through the heart, who still recovered, and lived for six years, and after his death the heart was opened, and the bullet found in it, in the right ventricle, lying against the thin muscular wall between the two ventricles. Nothing but the result of the *post-mortem* examination could have made such a case credible.

The development of the heart from its very earliest stage is interesting and remarkable. In tracing the early development of the higher animals, we find successive stages of progress, each stage corresponding almost exactly with the permanent or perfect state of a class of animals below that in question.

The heart, for instance, of all vertebrate animals is at first very like the circulatory organ, for a heart we can scarcely call

it, which is found in the perfect state of some of the lower invertebrata. It then attains the state of perfection in which it is found in fish, going no farther in that particular class; but in Batrachians, after passing through the first two stages, development is not arrested as in fish, but goes on to a higher state of perfection. In reptiles, the first three stages being passed through, advance is still made; while in the heart of birds and mammalia, including man himself, the highest state of perfection is at last reached only by passing through the others.

Accordingly, the earliest form in which the heart presents itself is as a solid compact mass of embryonic cells, not differing in themselves from the cells of which other organs of the body are constituted, since the cell is the primordial form in which essentially vitality resides, and of which all organized bodies are entirely composed. At first there is no cavity in this heart, but shortly afterwards the cells in the centre seem to exert repulsive force on each other and become separated, thus forming a cavity which, however, is still closed; a liquid next appears in the cavity, in which the central cells may be observed floating; but even before this, or before even the formation of a cavity, pulsation is observed to take place among the cells. To what such pulsation is owing is beyond our present, or perhaps our possible, knowledge; the cells are similar to those in other parts of the body, and yet from their very earliest laying down in this position, and mutual relation, the function begins which the organ is to discharge during the whole period of existence. These pulsations are at first very slow, about fifteen to eighteen a minute, and they simply propel the contents of the cavity to and fro. So far, then, the heart is analogous to the first shadowing forth of a circulatory system which we see in the lowest of the animal sub-kingdoms, the Protozoa, in whose transparent, gelatinous, celluliform bodies one or more clear pulsating spaces are observed in the interior of the cells, and which appear in some degree to effect a circulation in the soft substance of the body.

The fluid within the cavity soon afterwards assumes the characters of blood, having been at first a homogeneous fluid, like the circulating fluid in the class of insects. About the same time the cavity opens, forming communications with the great vessels in contact with it which have been developing themselves *pari passu*, and subsequently the cells of which the walls of the heart are composed, are transformed into fibrous and muscular tissues, and into epithelium, which is a name applied to the cells which constitute lining membrane, whether externally as the skin, or internally, as the mucous membrane.

About the same time the heart, which was a straight cavity hitherto, becomes curved like a horse-shoe, and shortly after-

wards divides into three cavities, which contract in succession; one of these is an auricle, another is a ventricle, and the third is a large bulb, which receives the blood as it leaves the heart. The heart has thus assumed the condition in which it exists permanently in fish, namely, a two-chambered cavity; for the bulb must be regarded as a vessel, and indeed soon splits up into a number of arches, which remain permanent in fish, and carry the blood first to the branchiæ or gills, and afterwards round the body; but in higher animals these arches become closed after a time, with the exception of three, one of which remains persistent, and forms the arch of the aorta; a second is the vessel which we mentioned above as connecting the right ventricle with the arch of the aorta before birth, and becoming closed in one part soon after birth; and the third is a similar vessel on the right side, which, however, becomes closed before birth. The part of the second one which remains open, gives off the artery to the lungs, which, of course, remains persistent; and some parts of the other closed arches still remain open, and become the arteries for the head and arms.

Next in order, in the development of the heart itself, comes the separation of the auricle into two chambers, thus giving us the heart of the Batrachians and lower reptiles (an opening, however, still remaining until birth, as is mentioned above); and then a division is formed in the ventricle also, which is completed before birth, and is found in the crocodiles, birds, and mammalia, including man himself. The bulb mentioned above becomes swallowed up in the ventricles, and the partition, after separating the ventricle into two, goes on, and separates the base of the bulb into two, thus separating the roots of the pulmonary artery and aorta.

We have thus given a brief outline of the structure, functions, and development of the heart, that beautiful machine by which circulation is kept up and nutriment supplied to all parts of the body. Who can witness such contrivance, such resource and ingenuity, without feeling himself compelled to acknowledge the existence of an Almighty and benevolent Designer? If it be true that "the undevout astronomer is mad," much more, we think, is the undevout anatomist, and they most unjustly libel the science, who say that the study of it has a tendency to foster atheistic sentiments.

We have seen this machine, the heart, at rest, as it is presented to the view of the anatomist, both at various stages of its development, and in its perfect state. It is possible even to witness it in motion discharging its functions, as it is presented to the view of the physiologist, yet even then we should have seen but the commencement of the wonders that exist there; for what those mysterious forces are which first develope its struc-

ture, and subsequently retain it in action, endowing it with that exquisite irritability or sensitiveness by which it becomes, on the application of suitable stimuli, a working, nay, a living and self-repairing machine, or what even is the essential force in those stimuli,—these are things which neither the knife of the anatomist, the microscope, nor chemical analysis, nor any other re-agent at our disposal can reveal.

Indeed, it is probable that they are beyond the scope of our present faculties to comprehend, yet they also are the works of the Creator, and, doubtless, intended to display His power and skill to intelligent beings; so that from our very ignorance and incapability for such knowledge here we are led to hope for a higher state of being, where, with more perfect faculties, we may be permitted to satisfy the longings of the mind for a knowledge of the hidden laws of the Creator, and so of the Creator himself, and to explore all those mysteries of nature which here are among the things unknown.

MISCELLANEA.

SCIENCE IN THE PROVINCES.

THE NORTHAMPTON SCIENTIFIC FESTIVAL.

RESIDENTS in the metropolis, unless they frequently visit the country, are little aware of the rapid strides which science is making in our provincial towns, of the number of votaries it enlists, and of the powerful influence exercised by these upon their less-informed neighbours, who have hitherto been completely absorbed in trading pursuits, but into whose minds the man of science is now beginning to infuse somewhat of his own intelligence and enthusiasm.

And not alone do the provincial associations elevate the taste and instruct the minds of those resident in their own immediate neighbourhood, but already they are to some extent contributing to the general fund of useful information by local exhibitions, and the results of local research.

A wise step has recently been taken by the department of science and art, in allowing the "Travelling Museum" of science to circulate throughout the country; and better still will it be if this museum be made to partake of the nature of a large snow-ball, and to gather substance as it rolls; for there is no doubt that most of the localities in which it is likely to be exhibited, would be both able and willing to send contributions to the central repertory of knowledge.*

But to return to our local institutions. About this time last year there was exhibited in St. George's Hall, Liverpool, about as excellent a collection of objects of natural history as we have ever seen in any provincial city in England, and everything possible was done to lend a charm to the exhibition.

So far as our memory serves, all the objects (with two or three trifling exceptions) were the property of private individuals, or public institutions, in the town and its vicinity. The Botanic Gardens sent its plants; the Museums of the town their stuffed animals and aquaria; local collectors exhibited their shells, minerals, and flowers; local fair ones provided refreshments and decorations; local *prowess* lent its martial strains to charm the ear; and local philosophers added their efforts to give a lasting aim to the exhibition, by delivering short addresses on scientific subjects.

Unfortunately "we" had at that time not yet seen daylight, and were

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* It may not be generally known that the Committee of Council on Education have recently authorized the consignment of objects for exhibition in connection with the demonstrations of science classes, &c., in country towns. We are not acquainted with the conditions on which the "museum" is sent, but this information may be had on application to the Secretary, South Kensington.

consequently unable to record the proceedings; but Liverpool is not the only town that brings her offerings to the altar of science, and we are now able to notice a similar display, which was recently made in the smaller but not less important town of Northampton.

For this exhibition the inhabitants were indebted to the chemistry and natural history classes of the Mechanics' Institution, and it was a great success in everything, except its pecuniary results. It contained collections of objects of natural history; of archæological interest; and illustrative of scientific theories and various manufactures. These were numerous and well arranged, each object being labelled with a simple description of its nature and uses; and gentlemen well versed in the various branches of science were in attendance to give any explanations that might be required.

The industrial occupations and staple trades of the town and neighbourhood were well represented. Samples of wool and specimens of cloth in different stages of manufacture were exhibited by Messrs. P. P. Playne and Co.; of needles in their different stages, by Messrs. Millward and Sons, Redditch; of cocoa, by Messrs. Cadbury and Co., Birmingham; the different stages of the silk manufacture were shown by Mr. Scott; chemical preparations by Mr. Harris, of Northampton.

The local tradespeople sent philosophical instruments, pianos, tobacco, machinery, &c.; a printing machine was at work striking off copies of a commemorative poem, of which more hereafter; and as in the Liverpool exhibition, the gentlemen of the neighbourhood contributed numerous collections of objects in zoology, archæology, &c. In the course of the evening a series of dissolving views were exhibited, and, lastly, what to a stranger would have been by far the most interesting feature in the exhibition, a potter and a papermaker were at work at intervals in the same room.

As is usual in such undertakings, although a great many persons contribute materials for the show, there is always some one who "does" everything. The factotum of the exhibition was Mr. Harris, of Gold-street, to whom the greatest credit is due for the manner in which this exhibition was conducted.

Our informant says nothing concerning the musical strains which usually enliven these festivals, nor are we informed whether the fair ladies of Northampton followed the example of those at Liverpool, and spent weeks beforehand in preparing decorations to grace the exhibition; but one at least, whose *nom de plume* was "Laura," won laurels by the composition of some beautiful verses, which were printed and sold in the building, the proceeds going towards the expenses of the exhibition.

After referring to the events of the past year, and paying a graceful tribute to the memory of one whom the fair poetess styles "Sage, Artist, and Prince," she thus characterises the aim of those who have promoted the festival:—

> Do ye ask for our aim?—Towards the Temple of truth
> With steady resolve and high purpose we tend—
> Her pilgrims are we! Nor with vanishing Youth,
> Nor with fugitive years, must our pilgrimage end.

True—we ne'er may be joined to that Hierarch band
Who with foreheads unveiled, view her lustre divine!
But at least in the Porch we may rev'rently stand,
And kindle our lamps at the fire on the shrine.

True—the watcher must sleep, and the lamp must expire,
And the fountains of life become frozen and chill,
And the eye lose the lightning that filled it with fire,
And each pulse of Emotion and Passion be still.

True—of us and our acts may no record remain,
Save a Memory treasured in bosoms that love us;
But, "Peace to his ashes—he lived not in vain,"
Shall be the fond requiem that's uttered above us.

And now let us pass from the consideration of science in its most practical application, from cloth, silks, needles, and edibles, to its less utilitarian aspect. Let us quit the halls of the Northampton Mechanics' Institute, with their display of the works of nature and art, and travelling for an hour or so along the Midland Railway, let us enter the green fields round about Burton-on-Trent, and there study—

Fairy Rings.

In Burton there is an excellent institution called the "Midland Scientific Association," which reckons amongst its members a veteran botanist, the Rev. Gerard Smith.

This gentleman has devoted much time to the investigation of the so-called "Fairy Rings," objects well-known to the child of the humblest cottager, but the nature of which has puzzled the ablest men of science.

How is it that these grassy circles (which were in former times believed by the ignorant to have marked the footsteps of "fairies in their nightly revels") constantly increase in diameter without any visible cause?

Are they really produced by

—— "The nimble elves
That do by moonshine green-sour ringlets make,
Whereof the ewe bites not; whose pastime 'tis
To make these midnight mushrooms?"

Do these fairies, these creatures who still impart romance to the dreams of our childhood, really leave these verdant circles as fit emblems of their eternal youth?

The reverend botanist thinks not; so we will not only bow to his opinion, but we will also transcribe a few of his remarks on the subject.

"Fairy rings consist, generally speaking, of circles or parts of circles of grass, of a darker colour and more luxuriant growth than the surrounding herbage, the outer edge of the circle being well defined, while the colour and stature of the grass diminish and fade so gradually inwards that it is difficult to determine the exact limit of the ring towards the centre. Very commonly there is to be observed an outer and contiguous ring, much narrower than the inner, and of which the grass is either short and weak, or faded and brown, remarkably contrasting with the vivid green of the inner ring. On this brown ring, or just upon its margin, fungi

are found. The duration of fairy rings varies much; some disappear in a few weeks, others endure for years. A severe winter will obliterate the external traces of a ring, and prevent the usual crop of fungi appearing upon it at the proper season; but such rings often reappear, and are thus considered to have been suddenly formed. During the whole course of their appearance the rings increase in diameter, spreading outwards from the centre; the faded brown circle becoming rank with green and copious grass, and a fresh outer circle being formed of dead or feeble blades of grass. The rate of increase is various; some enlarging their diameter a few inches in the year, others as many feet. The circles frequently meet in the course of this gradual enlargement. In such cases the point of contact becomes obliterated; and when this contact occurs between the margin of several such rings the obliteration of the parts which meet leaves a variety of segments of circles upon the turf, which pursuing an independent course, and some increasing more rapidly than others, present eventually an unaccountable irregularity, and, as it were, patchwork of greener and paler, stronger and weaker portions of turf. When the turf is cut through such a ring at two contiguous points so that a breadth is taken up from the inner rank green, through the faded breadth, to the outer ordinary state, the soil of the faded ring is always found drier and of a paler colour than the adjoining parts, and abundantly impregnated with Mycelium. Indeed, a careful examination will show that the faded and impoverished condition of the turf of the outer ring, is due to the close investment of its roots by the mycelium of the fungi, which occupy the ring. The dimensions of the rings vary from 3 feet to 300 feet in diameter; they are at times very irregular in form, an accident arising either from the nature of the soil and the obstacles which they meet with in their circumferential expansion, or from more than one ring coalescing, and producing an outline of undulating curves. Such are the usual characters of these phenomena."

After giving a lengthened account of the various scientific theories, by which it has been sought to explain the appearance and growth of fairy rings, Mr. Smith accounts for them as follows:—

"The fungi," he says, "which are found just upon their margin, 'exhaust the fertility of the soil, in which their mycelium* prevails.' The ring then extends beyond the exhausted portion into the new soil. But both the *inner* as well as the *outer* portions of a 'fairy ring' have a decayed appearance; and on this head," the author continues, "careful examination of the impoverished grasses upon the burnt and faded ring will show that it is the mycelium investing the roots of the grasses themselves that occasions the decline of their growth, and not seldom their death." When, however, the "mycelium" has performed its functions, and produced young fungi, it decays; and instead of extracting the nutriment from the soil to the *injury* of the grass, it serves as a manure to its luxuriant growth. *Within* the ring the long grass has exhausted the soil, so it now spreads outwards, and widens in circumference; in short, to quote Mr. Smith's recapitulation, "the true explanation of the phenomena of fairy rings appears to be, first, the natural process of vegetation advancing from exhausted to virgin soil; secondly, the impoverishment of the turf by the investing mycelium of the fungi; and, thirdly, the revivifying and fertilizing effects of the decaying mycelium upon the same turf once withered and dried."

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* The "Mycelium" is the interlacing filament from which the fungi spring up.

WARWICKSHIRE NATURALISTS' FIELD CLUB.

THE winter meeting of the Warwickshire Naturalists' Field Club was held at the Museum, Warwick, on Thursday, the 13th instant. This was a joint meeting of the Malvern Club with the Warwickshire, and was tolerably well attended, though not so numerously as the occasion merited.

In the absence of the president, the Rev. P. B. Brodie, F.G.S., the Vice-president, took the chair. He opened the business of the day by welcoming the members of the Malvern Club, and then reviewed briefly the proceedings of the Warwickshire Field Club during the past year. He then called upon the Rev. St. John Parry, president of Leamington College, to describe a portion of an antler of the Red-deer, which had been found in certain beds of clay, supposed to be London clay, near Gosport. It exhibited marks of a knife or halbert; and a short discussion followed as to the true nature of the deposit in which it occurred; and the geologists present were unanimously of opinion that the clay would be found rather to belong to a drift than so old a formation as an eocene tertiary stratum. The Vice-president called upon the Rev. W. Symonds, president of the Malvern Field Club, to deliver his address on geological facts and theories. He commenced by giving an astronomical view of the history of the earth, combated the idea of an original universal molten condition of our planet, alluding to the early and first traces of life in the lowest or Cambrian rocks; and gave a brief review of Darwin's theory of the origin of species by natural selection, to which he expressed himself decidedly opposed, and so passed on to other interesting geological facts and theories.

The Rev. P. B. Brodie then gave a lecture "On the succession of life on the ancient earth." It occupied an hour and a half, and it is impossible, in a brief sketch, to enter into all the interesting subjects of which it treated. It was an extempore discourse largely illustrated by numerous drawings, diagrams, &c., which fully illustrated the topics discussed. The lecturer pointed out the influence of climate on land, and depth in the ocean, on the distribution of life. All the great types of life, he said, began simultaneously and independently. The life of the Palæozoic rocks was shown to be entirely marine, which was fullest in the Wenlock and Ludlow groups. Fishes and land plants first appear in the uppermost Ludlow zone. Ere the close of this epoch many forms of mollusks disappear, and are succeeded by other new and representative forms, to which ample allusion was made, in the succeeding formations up to the newest tertiary. The structure of the singular Placoid and Ganoid fish was pointed out, especially those of the old red sandstone, also of the Cycloid and Ctenoid orders, commencing with the chalk. The thirteen orders of reptiles, five of which are both recent and fossil, were largely dwelt upon and traced upwards from their first appearance in the Carboniferous series to their gradual extinction upwards. The structure and nature of the Salamander, like Labyrinthodon, was especially referred to, as the Warwick Museum contains the finest collection of the remains of this extinct reptile in the kingdom; and a fine suite of footsteps was exhibited to the meeting. The rev. lecturer thus traced the gradual development of life, from the lowest strata upwards, referring to the successive appearance of insects, myriapoda, reptiles, birds (some extinct), and, lastly, of mammals;

and concluded his address with a brief summary, reviewing this gradual development of life as indicative of a definite creative plan which binds the whole into one harmonious system.

Complimentary votes of thanks were then passed to the various lecturers by the audience, which consisted of the members of many neighbouring clubs, and included, we need hardly add, a great many of the fair sex.

The remainder of the day was spent in social intercourse between the members.

THE FIFTIETH ANNIVERSARY OF THE LIVERPOOL LITERARY AND PHILOSOPHICAL SOCIETY.

Liverpool possessed a Literary and Philosophical Society in 1790; not the one which has just celebrated its fiftieth natal day, but another, with which was connected the name of Edward Rushton, the founder of the "School for the Blind," an institution which still calls forth the admiration of all strangers who visit Liverpool.

The present Literary and Philosophical Society was founded on the 13th March, 1812, when fifty-six gentlemen enrolled themselves as members; but it was not until December, 1817, that the Society rendered its name permanent by the election as member, and on the same evening as its president, of William Roscoe.

Here is Mr. Roscoe's letter to the secretary, accepting office:—

"My Dear Sir,—May I beg that you will take an early opportunity this evening to express my respectful thanks to the Literary and Philosophical Society for the honour they have done me, and which you so obligingly announced to me, in admitting me a member and nominating me to the distinguished situation of their president, a situation the duties of which I shall be happy to discharge to the utmost of my power. If it will not be informal for me to make my appearance amongst you this evening, I will be in attendance in the ante-room, and will wait their pleasure.

"I am, my dear Sir, most faithfully yours,

"W. Roscoe."

Mr. Roscoe was introduced at the evening meeting, the members rose to receive him, and he signed the laws.

Amongst the gentlemen known in literary and scientific circles, who have since held office as presidents, we may mention Dr. Traill, J. B. Yates, F.S.A., Dr. Booth, F.R.S., Dr. Dickenson, F.R.S. The present occupier of the presidential chair, the Rev. H. H. Higgins, is most zealous in his encouragement of science, being an acting Vice-president of the Naturalists' Field Club; as is also Dr. C. Collingwood, the secretary of the Literary Society; a gentleman well known in the scientific world for his contributions to natural history.

It is no wonder that a society which, as our readers will perceive, has acquired more than a local reputation in the annals of science and literature, should seek to give some *éclat* to the silver year of its existence; and we find accordingly, that under its auspices the town-hall of Liverpool was thronged on the 13th of last month with a concourse of nearly 1,500 ladies and gentlemen.

The "west drawing-room" was devoted to the exhibition of philosophical

instruments, electrical and other experiments, and telegraphic printing; the "east drawing-room" to books, autographs, and manuscripts; the most conspicuous of the last-named being one of Roscoe's, of the Life of Leo X. The remaining saloons were devoted to the arts, to music, and painting; and the Council-chamber, &c., to refreshments.

The music consisted chiefly of part-songs, beautifully executed by the German "Lieder Tafel." The paintings in oil and water-colours, which were the property of the merchants and gentry in and around Liverpool, were collected and well hung under the superintendence of Arnold Baruchson, Esq., a patron of art in the town.

The Rev. President delivered a short address in one of the saloons during the evening, in which he sketched the history of the Society; and his place was then occupied by the only surviving founder present, the venerable and much-esteemed William Rathbone, the friend of Roscoe, as well as of all that is good and useful in Liverpool. He addressed those around him as his "children," and called up old associations in the minds of many who had lived with him when science was a heresy. After these addresses the concert followed, and brought the proceedings of the evening to a close.

Such meetings as this, and others, of which we hope to be able to record a goodly and increasing number in each new issue, are calculated to place science in its true light, not as a dry study, hemmed in by obstacles insurmountable by the populace, but as one of the chief occupations that render life useful and agreeable.

We congratulate the Liverpool Society on the success of its fiftieth anniversary, and hope that *it* may live to celebrate, and that these pages may record, the hundredth year of its existence.

TRANSLATIONS AND CONTINENTAL NOVELTIES.

The Kangaroo and her Young Offspring.—Die Natur, a weekly popular magazine of science, edited by Dr. O. Ule and Dr. K. Müller, and published in Halle, contains a series of articles by the first-named writer on "Marsupials Recent, and Fossil;" from one of which we extract the following wonderful anecdote connected with the natural history of the Kangaroo:—

"Weinland observed an interesting circumstance in connection with the development of these creatures in the new zoological garden, Frankfort. In the winter of 1860, a female kangaroo had given birth to a young one, which for the first time protruded its naked head, measuring two inches in length, from the maternal pouch on the 22nd of February. Towards the commencement of May, it ventured forth for a little while upon its own feet, and in the course of the summer it continued to disport upon the grassy lawn, and to grow in stateliness and beauty, under the guardianship of its parents.

"Although it had, in the month of September, attained to half the size of its parents, it was still frequently seen to seek refuge in its mother's pouch. With long leaps it would, at such times, come bounding towards her, under the apprehension of some imaginary danger, and without an instant arresting its progress on approaching her, it would plunge head foremost into the half-opened pouch of the mother, who was quietly seated upon her hind

legs; and twisting itself rapidly within the pouch, it would protrude its head with an irresistibly comic expression, indicative of a sense of security. Towards the end of September this young one, which was also a female, was seen in the pouch for the last time; but although it relinquished the *shelter* afforded by its parent, yet it continued to seek its nourishment from this source.

"On the 22nd of October the parent was still suckling her offspring, when to the utter astonishment of the observers, that peculiar tremulous movement was perceptible in the pouch of the *young one*, which left no doubt as to its condition.* Herself a mother; ay, even suckling her own offspring in her pouch, this creature still drew its nourishment from its parent."

War against the Locusts.—During the last two or three years Turkey, the Principalities, Bessarabia, and part of Russia have been visited by a plague of locusts; and we extract the following account of the means employed by the inhabitants of certain districts to stop the progress of these insects, from the same interesting journal which has afforded us the preceding anecdote:—

"It was supposed that the danger had passed away (June, 1859), when suddenly the news spread that incalculable swarms of locusts were on their way from Khersonese. A few days previously, indeed, these pests had crossed the Dniester at Bender. Forming a mass one and a quarter German miles (about four English miles), in breadth, and seven to eight inches thick, they occupied the whole of two days in swimming across the stream, and then spread themselves in all directions over the marshy lowlands lying on the left bank of the river. Here it was absolutely necessary to arrest their further progress, and a crusade arose, which, for violence and murderous results, is quite unprecedented in the annals of natural history.

"Germans, Bulgarians, Moldavians, Jews, and Russians, all hurried to the rescue, for each nation had its flocks and herds to defend from the terrible invaders, and in a brief space of time 14,000 well-armed men stood arrayed for the conflict.

"Meanwhile the locusts had occupied all the level country covering a superficial area of four square miles.† In order to prevent their inroads upon the surrounding fields, it was found necessary to excavate deep ditches in different parts along the boundary. These were guarded by persons whose business it was to kill the locusts as they fell into the ditches. The remaining people divided themselves into bands, or companies of hundreds and thousands, and with the aid of brooms and drags, constructed of dry branches, they commenced a vigorous onslaught upon the enemy as he advanced over the hedges and underwood, in ever increasing swarms. Wherever the ground was perfectly level, horses and oxen were employed in great numbers to trample the enemy under foot, and watchmen were appointed, who passed rapidly from post to post, and ordered bands of men to those portions of the boundary line which were in the greatest danger of being broken through by the advancing hordes of the enemy.

"The battle raged a whole week, during which three-fourths of the entire mass of locusts perished, and by this time the remaining insects had completed their metamorphosis, and were in full possession of their wings. On the 9th of July, the first swarms rose into the air, and flew off in various directions. Any further effort to destroy them was now deemed unnecessary, and the men were dismissed to their respective homes. But the slaughter had not been perpetrated in vain, for whilst in Khersonese the entire harvest had been destroyed by this insect, Bessarabia suffered but little."

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* The tremulous movement referred to, indicates the birth and descent into the pouch of the partially-developed young of these animals.

† Four square German miles = about thirty-six square English miles.

REVIEWS.

METALLURGY.*

THE extraction of metals from their ores, and their manufacture for the various purposes for which they are peculiarly adapted, has necessarily been studied from the very earliest ages of antiquity, and has always awakened the energy and zeal of even the rudest and most unlettered tribes. The savage soon learned that, to practise the art of war successfully, he must obtain a substance harder and more durable than wood from the forest or stone from the quarry; a substance which could be forged, hammered into shape, tempered, and refined—processes which could not be employed in the workmanship of wood or stone. He learned, from experience, that his enemy, when fortified with metallic implements, although perhaps inferior in physical strength, had a power of endurance and defence superior to his own. Besides the warlike arts, the genial pursuit of agriculture and the comforts of domestic life were soon found to be dependant upon the application of substances, at once hard, durable, and comparatively pliable, and these acquisitions were only to be obtained in the metals. It would be curious and interesting, did our space admit, to speculate upon the rude metallurgy of those early days when Tubal Cain smote the anvil with his hammer and welded iron for the first time.

The ancients, as far as we can learn, were only cognizant of seven metals—gold, silver, copper, iron, lead, tin, and mercury—to each of which a symbol was assigned, in honour of some great object in Nature or a popular deity. Hence gold, the source of luxury and wealth, was called the sun; silver, the moon; copper (probably owing to its beautiful colour), Venus; iron (from its strength and employment in battle), Mars; lead, Saturn; tin, Jupiter; and Mercury, from the god of the winged heel. Zinc, although of no modern discovery, was only first mentioned by Agricola; the other metals being of more recent date.

Our forefathers, doubtless, were familiar with many of the earths, salts, &c., with which we are acquainted, but from want of analytical skill they were ignorant that these substances were metallic compounds. They knew not that the salt with which they preserved their food was merely the chloride of a metal—white and lustrous as silver,—that the chalky cliff and marble steep, the branching coral and glistening shell, were the carbonate of a metallic oxide,—that the ashes of their forests and the granite of their rocks contained a metal, which, in future ages, the genius of Davy would disclose.

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* *Metallurgy: The Art of extracting Metals from their Ores, and adapting them to various purposes of Manufacture.* By JOHN PERCY, M.D., F.R.S.

In short, that the whole world itself, from the summit of its loftiest cordillera to the seething mass within its centre, was one vast sphere of metal, tarnished and dimmed by contact with surrounding elements.

And our forefathers, probably, distinguished the few metals with which they were acquainted more by their physical than their chemical characteristics. They knew that lead had not the lustre of silver, nor the latter the yellow gleam of gold, nor gold the reddish hue of copper; that tin was too soft a material from which to form the offensive spear or the peaceful pruning-hook, the weapon of the warrior or the implement of the husbandman; and that hard, enduring iron must serve the soldier in the conflict and the farmer at the plough; but they knew not the salts or the chemical compounds of the metals. Were those metals disguised, as they are in solution, they could not distinguish them from one another.

Modern chemistry teaches us to investigate these matters more closely, not to be content with the condition of a metal in its elementary form, but to understand the reaction it imparts when in combination with other bodies, and hence by certain and unerring tests to be able to affirm its presence, even when its metallic form is hidden from our eyes. Knowing the characteristic colours which the metal chromium can yield to certain transparent minerals, we can recognize its acid blazing in the ruby, or its oxide gleaming in the emerald's milder light; or cobalt, in the sapphire glass of some old cathedral; or manganese, in the amythestine spars of Derbyshire. Every metal can be known by certain phenomena which always accompany its combination, by the colour it gives to fluxes, or by the tints it imparts to flame.

During the last century, what numerous metals have been brought to light! The ancients recognized seven only—we are acquainted with about fifty; and the increased range of our experience has led us to alter, in certain respects, our preconceived notions of their characteristics. Metals were always described in earlier treatises as essentially *heavy* bodies, having a far higher specific gravity than water, but science has given us several which are much lighter than that liquid (such as potassium, sodium, and lithium); in many points, however, such as being good conductors of heat and electricity, they possess properties in common. Their chemical, as well as their physical characters are exceedingly diverse, some combining with oxygen with such avidity, even at ordinary temperatures, as to lose their metallic appearance after a few moments' exposure to the atmosphere, whilst others can be submitted to the strongest heat for many hours without suffering any change. It is interesting to trace these phenomena, as exemplified in the various metals, beginning with potassium and terminating, perhaps, with platinum or gold. Potassium, even in dry air, is soon converted into potash, and, as far as its metallic nature is concerned, would instantaneously perish in the dewdrop. Magnesium, although not so strongly affected, burns in the flame of an ordinary candle, emitting, during its combustion, the most vivid and beautiful light. Iron, the very symbol of enduring strength, speedily becomes oxidized, and, unless carefully shielded from external influences, rusts into the earth from whence it came. Copper, although in a less degree, soon becomes tarnished and grows dim. Even silver loses its lustre after the lapse of years, and cannot withstand the

action of the sea—for the treasure which Anson failed to capture, sunk by the Spaniards from their argosies, was found, after some time, to be coated with the chloride. While gold for ever would withstand the action of wind and wave, and only passes through the furnace to be purified and exalted *from* its fires. Undimmed by the breath of Time, unharmed by the wear of centuries, unaffected by the all-conquering oxygen, the metal first dug from the bed of the Euphrates, or quarried from the caverns of Ophir, is still fresh and brilliant as the glittering coinage of to-day!

The advancement of chemical science has, while leading us into a clearer knowledge of the properties of the metals, naturally taught us to investigate the various phenomena which accompany their extraction from the elements with which they were in intimate association, and the subject has proved so inviting that many philosophers have devoted years of laborious life to this special branch of technology. The work now before us offers a fair example of what long continued and patient experiment can effect; and the subject has evidently so grown under the author's hands, that, although we believe it was his original intention to comprise the whole matter in one volume, that which is already published only treats of two metals and their compounds, together with an elaborate treatise on Fireclays and Fuel. Another volume is promised shortly, which, it is stated, will conclude the work; but if we are not much mistaken, two or more will not contain all the important particulars the author has at his command, as we have yet to become acquainted with iron, lead, silver, gold, platinum, nickel, cobalt, arsenic, bismuth, antimony, tin, and mercury, all of which possess a very high, although not perhaps an equal interest.

Dr. Percy commences his introductory chapter by showing that a sound knowledge of chemical and physical laws is essential to the full understanding of any metallurgic process, and as an illustration, the ordinary system of copper smelting is adduced: "When an ore of copper, consisting essentially of copper, iron, sulphur, and silica, is subjected to a series of processes, such as heating with access of air under special conditions, melting, &c., copper is separated in the metallic state. The sum of these processes is termed the smelting of copper. In this operation of smelting, certain chemical changes take place. The sulphur combines with the oxygen of the air, and is evolved chiefly as sulphurous acid; the iron is similarly converted into oxide, which combines with the silica present, to form a fusible compound or slag. There are thus several facts which are proved on chemical evidence. These facts, when systematically arranged, may be said to constitute the scientific knowledge of copper smelting; and that knowledge necessarily implies a knowledge of the chemical relations of copper, iron, sulphur, oxygen, and silica to each other. There are many other facts connected with copper smelting, but those mentioned suffice for the present purpose of illustration. The man who conducts the process of copper smelting in ignorance of these facts, has simply an empirical, in contradistinction to a scientific, knowledge of the art."

We are then led on to the physical properties of the metals, the action of heat, the fixed and the volatile metals, specific gravity, crystallization, varieties of fracture, malleability, ductility, tenacity, toughness, softness, the relative power of conducting heat and electricity, &c.; and under this last head

the results of some very interesting experiments of Matthiesson's are given, showing that the conductibility of metals depends not only upon their chemical purity, but also upon their molecular structure. Hence, the conducting power of pure silver wire, *hard drawn*, is stated as equal to 100, but when *annealed** it is 110; and copper, which possesses the same power to a nearly equal degree, viz. 99·5, when hard drawn, only increases to 102 when annealed. The practical importance of these experiments must be apparent to every one, as upon the conductibility of metals, the whole system of the electric telegraph depends.

A great portion of the work is devoted to the study of the various kinds of fuel used at different periods for metallurgic purposes, and in the article upon coal there is an interesting notice of the occurrence of certain metals in the fuel we ordinarily consume. Daubrée has detected traces of antimony and arsenic in the coal of Newcastle-upon-Tyne, and in a variety of coal at Ville, in France, as much as 0·0415 per cent. of arsenic, besides traces of antimony and copper. "I have seen," continues Dr. Percy, "galena (sulphide of lead) in coal from Bedworth, and the anthracite of South Wales, which we have been accustomed constantly to employ in the metallurgic laboratory of the school of mines, contains decided traces of copper."

The subject of copper smelting is entered into minutely in all its important bearings, commercial, statistical, and scientific. Speaking about the enormous amount of poisonous gas annually exhaled from the copper-works of Swansea alone, Dr. Percy quotes Le Play as the author of the following interesting facts:—"Sulphurous acid forms twenty-one per cent. of the total weight of the sum of the fixed and volatile products of calcination, and twenty-five per cent. of the weight of the ore subjected to calcination; the weight of sulphur contained in this gas amounts to thirteen per cent. of that of the ore. During the entire process of smelting, the sulphurous acid and sulphur expelled amount, respectively, to fifty-six and twenty-three per cent. of the weight of the ore. The total weight of copper ore smelted in South Wales (some time before 1848) being about 200,000 tons, about 42,000 of sulphur were annually volatilized, producing 92,000 tons of sulphurous acid. In the works situated near Swansea, nearly two-thirds of the ore imported into South Wales are smelted, so that daily 65,900 cubic metres of sulphurous acid are projected from these works into the atmosphere. This acid, being very hurtful to vegetation, not a blade of grass will grow on the neighbouring hills, which are particularly exposed to its influence. The sulphuric acid contained in the copper smoke is probably more injurious than the sulphurous acid, as every drop of rain, in falling through the smoke, becomes a solution of oil of vitriol, which, alighting upon foliage, is rendered more corrosive by subsequent evaporation of a portion of the water. The value of the sulphur annually dissipated is estimated at £200,000."

The elimination of the various metals usually found associated with copper

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* The process of annealing generally consists in allowing the metal to cool *gradually*, during which operation certain valuable properties are conferred upon it, depending, it is supposed, upon a different state of the physical arrangement of the atoms. When *hard drawn*, the *annealing* has been dispensed with.

is a matter of very great importance. It would astonish those who have not devoted much attention to metallurgical pursuits, to learn how sensibly the most minute traces of foreign metals interfere with the value of copper, rendering it, in many instances, hard and brittle when softness and malleability are required. So delicate are the manipulations requisite for the detection and estimation of all the impurities, often amounting collectively to only a few hundredths of a grain in one hundred of copper, that many experienced analysts have disagreed materially in the results of their investigations.

The importance of a knowledge of chemistry to those who have the management of smelting works is well illustrated in an anecdote related by Dr. Lyon Playfair to Dr. Percy :—"At large chemical works, where sulphate of copper was prepared by dissolving copper in sulphuric acid, an insoluble residue was produced in the process, which had been put aside from time to time, and had not fortunately been thrown away. A small sum was offered by certain persons for this residue, which had not previously been regarded as of much value. Suspicion was excited, especially by the quarter from which the offer proceeded, and it was declined. The residue was examined and found to contain £700 worth of gold."

Dr. Percy does not seem to imagine that many improvements either in the economy of the process, or in the purification of the copper, have taken place during the last few years. Numerous patents have been registered, from time to time, for effecting not only a great saving in fuel, but also a better reduction of the metal, and yet nearly all the copper works have gone back upon the old system, the saving of time and fuel not appearing to compensate for the inferiority of the copper produced too rapidly. A smelter of great experience has assured Dr. Percy that better copper was formerly made by what was termed the *dry* roasting than that made at present by *wet* roasting. In the former case the regulus underwent a long course of treatment at a moderate heat, in which the volatile metals were eliminated ; in the latter the regulus is run down at once, and kept liquid until all the sulphur is expelled.

It is to be regretted that our space will not admit of even a hasty glance at the metallurgy of zinc, which concludes the volume before us, a volume abounding in facts of the greatest importance, not only to the practical smelter but to the political economist and the philosopher. The statistical accounts of the quantity of coal annually consumed in metallurgic operations, the imports and exports of metals in their rough as well as their manufactured condition, the smelting of other countries compared with our own, cannot fail to interest all those who have the advancement and prosperity of these kingdoms at heart. The plates with which the work abounds are no ordinary illustrations, apt to mislead the novice in metallurgy, but true and correct sketches, according to exact scale, every line and altitude being accurately delineated. We must congratulate the scientific world upon the addition of a book to its library so full of useful information, and we must also congratulate Dr. Percy upon the success which has attended his labours.

BRITISH POISONOUS PLANTS.

ILLUSTRATED BY J. E. SOWERBY, DESCRIBED BY C. AND C. P. JOHNSON. (SECOND EDITION.) JOHN VAN VOORST.

THE first chapter of this work, although it only contains four pages, is decidedly its most interesting and popularly useful portion. It treats of the nature of poisonous plants in general, and contains simple and practical directions for procedure in cases of poisoning before the arrival of the qualified practitioner.

Far be it from our purpose to terrify anxious parents by reciting any of the numerous cases of accidental poisoning in cases where persons have partaken of common plants; but we think they would be somewhat surprised, in glancing over the list, to find amongst them many that are considered perfectly harmless, and would keep a watchful eye upon their nursemaids and children.

The little work "owes its existence," we are told, to a case of accidental poisoning by a plant belonging to the buttercup (crowfoot) tribe. The common elder has caused death. The foxglove "is one of the most powerful of our indigenous poisonous herbs;" and (start not, youthful reader!) instances of poisoning by sorrel, or "greensauce," have *generally* occurred with children who had eaten it in considerable quantity.

The acid flavour of this herb, which is "in the mouth" of every child, is due to the presence of one of the most dangerous of vegetable poisons, namely, oxalic acid—which it contains in the form of binoxalate of potash; and it will be new to many of our readers that, "It is the above mentioned vegetable salt, obtained from common sorrel, that is now so generally met with in the shops of the druggists under the false name of 'essential salt of lemon,' for removing ink and other stains; a very small quantity of which acts as a powerful irritant poison. In one instance on record, a quarter of an ounce, administered by mistake, occasioned the death of a lady within eight minutes."

The whole book is full of interesting descriptions of poisonous plants, and we cannot do better than to extract a short one, as characteristic of the contents of the volume:—

"COMMON MONKSHOOD: WOLF'S BANE (*Aconitum Napellus*).—* * * * Every part of this plant is a powerful poison, and its action is often too rapid to admit of the effectual administration of remedies. The young leaves have been mistaken for parsley; the root on several occasions for horse-radish. The flavour of them both is totally unlike that of the vegetables for which they have been substituted, but this circumstance is either not attended to at the time or regarded as too trivial to excite more than a passing remark. The root of the monkshood has an earthy smell, and is bitter to the taste, without any very remarkable pungency at first, but soon produces a slight tingling and a burning sensation, attended with a kind of numbness and contraction of the skin, of the tongue, and roof of the mouth,—the pricking or tingling soon extends over the body and a feeling of constriction about the throat, occasionally amounting almost to strangling, induces the patient to frequently grasp it with the hand. The symptoms may vary according to age, constitution,

and other circumstances ; but headache, confused vision, restlessness, convulsive clenching of the hands and jaw, vomiting and diarrhœa, attended with severe pain in the abdomen, are the most prominent and ordinary. The time of death varies from one to eight hours after the poison has been swallowed, and hopes may be entertained of the patient's recovery if the fatal termination does not ensue within that period.

"The monkshood was introduced here as a garden ornament, or, more probably, as a powerful medicinal agent, at a very early period, and occupies at present a place in our 'Materia Medica,' or catalogue of remedies sanctioned by authority. It has no other claim to be considered as one of the wild plants of this country than that of being met with growing uncultivated in a few places in the western part of England. Its frequency in the garden, and the careless manner in which its deadly roots are often distributed, have induced us to place it, though only an interloper, at the head of our list of British poisonous plants. The recent accident in Scotland, where three persons died in consequence of the roots of the monkshood being brought in by a boy from the garden as horse-radish, and used by the cook, unconsciously, in preparing sauce for beef, added to many others of a similar kind, ought to render gardeners cautious in planting, and teach them to avoid placing this and other poisonous herbs in the vicinity of those employed for culinary purposes ; and no less so in their disposal of superfluous roots where there is a possibility of their being found by ignorant people and misappropriated.

"The education of the gardener himself, however, is, in too many instances, inefficient, as, even when well acquainted with the names of plants and the methods of successful cultivation, he is often altogether destitute of information regarding their properties and uses. * * "

Mr. Sowerby's plates are very beautiful, and we need not hesitate to say that, if anything, they surpass the text in excellence. This edition of the work contains four additional plates and descriptive text of the principal poisonous Fungi of Great Britain.

As to the publisher's share in the work, we shall only say it is a book after Mr. Van Voorst's own pattern ; and the beautiful coloured illustrations render it very suitable for the drawing-room table.

A Manual of Structural Botany. By M. C. Cooke. Hardwicke.

MR. Cooke has compressed into the smallest possible space, and the publisher has produced, at the lowest cost, all the information necessary to enable a teacher to instruct a class in the principles of botanical science.

An excellent feature in the little manual is, the explanation which accompanies every technical term ; and especially in the case of the chemical substances, which are very clearly explained ; as, for example :—

P. "Phosporus (Phos, *gr.* light ; phero, to bring) is not found pure in nature ; it is extremely inflammable, and emits, by slow combustion, a faint light visible in the dark. It is found in combination with those compounds of plants which contain nitrogen. During decomposition, phosphorus and sulphur enter into combination with hydrogen, and form phosphuretted and sulphuretted hydrogen ; with metallic bases phosphorus forms phosphates."

Why the terms kalium, natrium, ferrum, and cuprum, are not given in explanation of the symbolical letters attached to the respective metals we do not understand ; and we doubt whether it would not have been possible to find a more elegant and equally accurate translation for the word bromos than the

one given, but which we shall not repeat. The woodcuts, 300 in number, are clear and well executed, and will no doubt be useful to teachers in the preparation of diagrams and black-board sketches. Indeed, the book is one of the cheapest shilling-worths that we have met with, and deserves a large circulation.

Manual of British and Foreign Plants. By L. H. GRINDON. Pamplin.

THIS little work, which is a vocabulary of the scientific and familiar names of almost every known plant, including those "celebrated in literature, mythology, and holy writ," just reached us in time to test its efficacy, inasmuch as we were desirous of ascertaining the names of some rare exotic plants, of which the seeds are imported into this country for industrial purposes.

We found it exceedingly valuable for our purpose, and, having experienced its advantages, we can unhesitatingly recommend it to botanical students and collectors.

The Threshold of Chemistry. By C. H. HEATON, F.C.S. Chapman & Hall.

AN excellent handbook for beginners whose circumstances will not admit of their incurring much expense in entering upon the study of chemistry.

The definitions of the elementary terms are clear and good, and the illustrations useful in aiding the student to perform the necessary experiments.

There is, however, an absence of information as to the processes by which metals are obtained from the ores—a want which might have been supplied in some instances by the addition of a few lines. Mr. Heaton has deviated from the usual mode of classifying the metals; and his alteration appears to us to be anything but an improvement.

The book is an excellent one for teachers employed in the instruction of a class.

Elementary Treatise on Physics—Experimental and Applied. By Professor A. GANOT. Translated and Edited from the Ninth Edition. By E. ATKINSON, Ph.D., F.C.S.

OUR space will only admit of our noticing the first part of this excellent work. It is very clearly written, and freely illustrated with woodcuts. The definitions are in nearly all instances very clear and simple, but some objections may be made to the "general notion" of "matter," given in paragraph two, as being "that which possesses the properties whose existence is revealed to us by our senses," because this notion would include the *forces* of nature, viz., heat, electricity, &c., which, as well as matter, "possess properties whose existence are revealed to us by our senses."

The instances used as illustrations are also, in nearly all cases, very good, but in paragraph thirty-five, where a "hurricane" is spoken of as "a small mass, moving with great velocity," a more correct illustration might have been employed.

The engravings in it are of a superior kind, and the printing very sharp and clear.

Elements of Natural Philosophy. 2nd Edition. By JABEZ HOGG. Bohn's Scientific Library.

TO those who are not initiated into the mysteries of physical science, and therefore require a book written in the simplest possible style, this volume will prove acceptable. It contains a very large number of important physical facts, stated in the most simple and popular language, and illustrated by a considerable number of woodcuts.

The information given in it is of a very reliable character, and in nearly all cases it is up to the present state of knowledge in the particular point under consideration; but in one instance, at page 386, the old method of obtaining oxygen, by heating black oxide of manganese red hot, is still given, although the much more convenient and easy method of obtaining it, from a mixture of chlorate of potash and manganese merely by the heat of a spirit-lamp, has long superseded it. Some qualification is also desirable to be made to the statement at page 9, that "no direct pressure will break glass, if it be supported from behind." The volume is particularly suitable for those who desire *popular* instruction in physics.

SCIENTIFIC SUMMARY.

QUARTERLY RETROSPECT.

ASTRONOMY.

Figure of the Sun.—A photographic apparatus has been projected by Mr. De la Rue, by which it is intended to obtain pictures of the sun, in order to examine whether its disc be really circular, and more especially to determine whether it is flattened at the poles. The Astronomer Royal, however, considers this question to be settled, and is of opinion that the proposed instrument would not add any information to our knowledge on the subject. The enormous mass of measures of the solar diameter recorded at Greenwich, and other observations, would, he holds, be more a test of the trustworthiness of the instrument rather than the reverse. In fact, from twenty-five years' observations at Greenwich of the horizontal and vertical diameters of the sun (where 2,487 measurements were made of the former and 2,694 of the latter), it has been found that the horizontal exceeds the vertical diameter by only one-tenth of a second of arc—a quantity almost imperceptible.

Missing Nebula.—The evidence in favour of changes of form, and variability in the light of nebulæ, has hitherto been regarded with considerable suspicion by astronomers. That a single star should fluctuate in brightness presents sufficient difficulties in the way of explanation—that a whole swarm of stars could be extinguished at one and the same time, and not only it, but a distinct star in its neighbourhood—presents obstacles which are almost insurmountable in the actual state of our knowledge. The few nebulæ which Sir W. and Sir J. Herschel found to be missing whilst engaged in their surveys of the heavens were very naturally attributed to wrong entries, or to the original body having been a comet, both of which mistakes might have easily occurred. Even Sir W. Herchel's assertion that he had *actually* perceived changes in the nebula of Orion between 1780 and 1811 (which was, as Arago observes, *avoir pris la nature sur le fait*), and when he made use of the same telescope on both occasions, was looked upon with doubt by his illustrious son, although it has been verified of late years by M. Otto Struve. At present there can be no further doubt concerning the actual disappearance of a nebula. The object in question was situated at R.A. 4h. 13m. N.P.D. 70° 50′, and was discovered by Mr. Hind in 1851. It was again independently found by M. Chacornac in 1854, and observed by M.

D'Arrest four times in 1855 and 1856. With a telescope of four and a-half inch aperture, he describes it as "very bright." The writer of this notice stumbled upon it in the autumn of 1855, whilst searching for De Vico's comet, and not finding it in any catalogue of nebulæ, observed it as the object of which he was in search, as it bore an exact resemblance to a telescopic comet. It does not appear to have been looked for until the last few weeks, when to the great astonishment of astronomical observers, it was found to have *completely disappeared*,—not the slightest trace of it being visible in the most powerful telescopes, and even a star which was situated near it had dwindled from the tenth to the twelfth magnitude. Such a phenomenon as this completely alters all the former ideas and received hypotheses on the nature of nebulæ, and from the reliable evidence on which it is founded precludes all chance of error in the observation. Whilst following this subject, the attention of those observers furnished with good telescopes might likewise be turned on the undermentioned nebulæ, in which changes of lustre have been suspected by D'Arres.

The "faint nebula" Herschel, II., 99, is now (1855) of 1st class (bright nebulæ).

„ „ Herschel, II., 101, „ of 1st class „

The "very faint nebula," Herschel, III., 44, „ of 1st class „

On the contrary :—

The "bright Nebulæ," Herschel, I., 1, 23 and 104 are now faint nebulæ.

„ „ Herschel, I., 62, is scarcely perceptible.

„ „ Herschel, I., 119, called "very bright," by Sir W., and "bright" by Sir J. Herschel, is at present very faint.

Solar Eclipse of December 31st, 1861.—The total eclipse was observed pretty favourably in the south of France and Italy, and the north of Africa, but the detailed accounts have not yet come to hand. Mr. Talmage, who observed the partial phase at Nice, states that Venus was visible (at 3h. 25m. p.m.), but that none of the brighter stars could be seen, and that there was a semi-circular streak of red light close to the limb of the sun, which gradually diminished to two abrupt points. M. Schmidt, the astronomer at Athens, was very unfortunate in endeavouring to catch a glimpse of the total phase (the sun setting fully eclipsed near Phlious), and his account of his expedition recalls the days of earlier Greece. On December 25th, he left Athens, travelled over the Corinthian Isthmus, where he saw the effects of the great earthquake of Aigion, and proceeded to Longopotamos over Kleonä and Nemea to Hagios Georgion on the southern foot of the Trinkaranon. On the 30th he ascended Polyphengos to about 1,900 feet, but met with nothing but rain, north wind, cold, and darkness. *Haud ignarus mali, disco*, &c. &c. The transit of Mercury across the Sun's disc on November 11th, was observed at Adelaide (Australia), by Mr. Todd, as likewise at Victoria and Sydney. No phenomena were noticed. At Malta the heat of the sun was so great on that occasion, that Mr. Lassell was forced to construct a covering to shield him from the sun. He repeatedly fancied the planet to be elliptical, and when the limb of the planet touched the edge of the sun, the former took a "pear-like" shape. The diameter of the planet as measured by

M. Secchi at Rome was 9,08 seconds, which is smaller than that given by the tables now in use. Professor Secchi proposed to take a few more measures of this element, but this, he says, is very difficult on account of the termination of Mercury's disc which seems to be very faint at the edges. Mr. Baxendell at Manchester noticed its shape when touching the edge of the sun, as decidedly egg shaped, the small end of the egg being next the sun's limb. The excessive blackness of the planet, as compared with the nuclei of the spots, was very apparent.

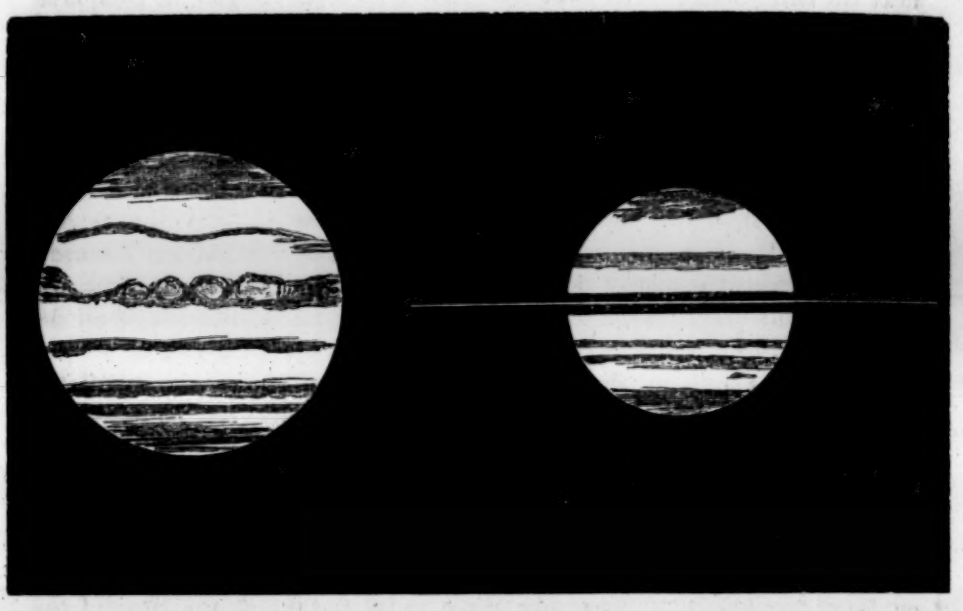
New Comet.—A telescopic comet was detected on December 29th, 1861, at 3 a.m., at Cambridge in the United States. It was independently discovered on January 8th, 1862, by M. Winnecke at St. Petersburgh. It was faint when first seen, and became much fainter subsequently. It was at its shortest distance from the sun on December 6th, being then at a little less than the mean distance of the earth from the central luminary. It approached within ten degrees of the pole star on January 20th. The great comet of July of last year was observed up to January of the present year. Astronomers must wait for the publication of all the observations, before its real orbit and true periodic time can be finally discussed. At present the latter element is doubtful—one calculator (Seeling) making its time of revolution round the sun 419½ years, whilst another (Capocci) concludes it to be 1,796 years.

Meteors.—Within the present year, M. Petit, of Toulouse, has calculated the height of the great meteor of September 13th, 1858. He finds its height to have been 222 kilometres (about 138 miles), and its velocity per second 19 miles. That which was seen and fell in France, on December 9th, 1858, was only three miles distant at the time of the explosion, and its apparent velocity was about three miles per second. It was twelve minutes after explosion before its luminous train had disappeared and violent detonations were heard.

Saturn.—The ring of this planet disappeared duly (as far as most telescopes were concerned), at the calculated time. For some days previous to this disappearance, the thin line of light into which the ring had resolved itself was considerably broken, as if various irregularities existed on its surface. Captain Jacob on December 4th, 1861, with the new nine inch telescope constructed for him by Cooke, detected a thin white line of light crossing a dark belt covering the equatorial regions of the planet. This was independently seen a few evenings later by Mr. Buckingham, and on Mr. Wray pointing his telescope at the planet on the morning of December 27th, he was astonished not only to see this (which appears to be the edge of the ring,) but also the continuation of this line of light projecting beyond the margins of the planet in the dark sky. The appearance is given in the accompanying drawing.

The thin trace of light across the planet seemed like a knife edge and was broken. It does not appear that this phenomenon was previously witnessed, although looked for by the Cambridge and Pulkowa refractors sixteen inch aperture at the disappearance of the ring in 1848. It is a striking proof of the improvement of object-glasses of telescopes—for which we are wholly indebted to English makers—Messrs. Way and Cooke.

Jupiter.—This planet is now beautifully seen, and always varying in appearance, as far as regards its belts and spots. The *third* satellite was observed by Mr. Wray as a dark spot whilst transiting the planet, on the morning of December 27th. The *fourth* satellite has frequently been noticed in this manner. The principal equatorial belt was compared to a string of beads on this occasion. (See diagram.)



JUPITER AND SATURN.

As seen by W. Wray, Esq., F.R.A.S., at 6h. a.m., with a 7 inch Object Glass.

New Planets.—Between February 11th and August 13th, 1861, nine new planets were discovered. Since the latter date none have been detected.

Miscellaneous.—Mr. Lassell has erected his four-foot mirror at Malta, and is greatly pleased with its performance. He has detected a new star in the trapezium of Orion. The gold medal of the Astronomical Society has been awarded to Mr. De la Rue.

CHEMISTRY.

I. PURE CHEMISTRY.—Some curious illustrations of the *divisibility of matter*, which have recently been drawn from chemical and microscopic science, will aptly commence our retrospect of progress made during the past quarter. The results do not, it is true, throw any light on the long debated question as to whether matter is capable of infinite subdivision, or whether it is built up of an aggregate of almost infinitely minute, but yet

definite and indivisible atoms; but they carry the mind down towards the infinitely small until it is lost and bewildered in figures and quantities overwhelming in their minuteness, in the same manner that a contemplation of astronomical magnitudes transcends human comprehension in their almost infinite vastness. The illustration is derived from well-known properties of the metal gold. A sheet of gold leaf in its ordinary form has a thickness of about the $\frac{1}{282,000}$th of an inch, and weighs the $\frac{1}{27}$th of a grain per square inch. If one of these leaves be caused to adhere to a plate of glass (by breathing on the latter, and placing it on the gold), and a very dilute solution of cyanide of potassium be applied at the edge of the leaf, it will pass between the glass and the gold, and the latter will be perfectly stretched out, and floated on the saline solution. The solvent powers of the cyanide of potassium will now exert themselves; the gold will be gradually dissolved away, becoming thinner and thinner until a film of almost any desired degree of attenuation is left. At any moment the process may be stopped by washing away the cyanide by water; if then alcohol be used, and finally alcohol containing a minute portion of varnish, the gold film may be obtained, cemented to the glass plate. This method of reducing the thickness of gold-leaf we owe to Faraday; by its means the thickness will have become reduced to about one-twelfth part of what it was originally, weighing (in round numbers) the $\frac{1}{600}$th of a grain to the square inch, and having a thickness of only about the $\frac{1}{3,000,000}$th of an inch. In this state the film presents none of the ordinary appearances of the metal, being perfectly transparent and resembling a delicate film of pale green varnish, more than a dense metallic substance. Chemistry having given us this near approximation to a mathematical surface, how far can it be subdivided mechanically? By subdividing this surface after the manner of Nobert, whose test lines are well known to microscopists, a small grain of gold—a fragment scarcely larger than a pin's head—has thus been divided into three billion, eight hundred and forty thousand million separate pieces, each one of which is capable of being distinguished under the microscope! In order to enable our readers to form some faint idea of the significance of such overwhelming figures as these, we may state that the proportion which each square bears to the original grain of gold is about the same that a thimble does to a building five times the size of St. Paul's.

The difficult subject of chemical nomenclature, so formidable a stumbling block in the path of students, has been attacked by Mr. J. A. R. Newlands, who proposes the adoption of a system of building up the names of organic bodies, whereby the exact formula of any substance can be told from the arrangement and position of the letters and syllables of the word. The result of Mr. Newland's system is that Hoffmann's celebrated substance, Methylethylamylophenylammonium, will find itself transformed into *Bafyldahylharylkahylammonium;* no great advantage as far as length or pronounceability is concerned, but being useful, inasmuch as its name represents the mode of arrangement of its elements, as well as its formula and exact composition. The insuperable objection to this and all other attempts to remodel chemical nomenclature is, that they are simply incapable of being introduced. If chemists would

consent to throw away their present knowledge and go to school again, such concentrated essence of language might be useful, but under existing circumstances its partial adoption would be injurious rather than beneficial.

The phenomena of *phosphorescence* are well known to accompany many chemical changes. These have recently been studied by Reichenbach, who shows that phosphorescence, or the continuous emission of light in darkness, is a much more common occurrence than it is usually supposed to be. Thus there is phosphorescence during fermentation or putrefaction, crystallization, evaporation, condensation of vapours, the production of sound and the fusion of ice; a considerable glow is remarked when a galvanic pile in activity, a block of ice undergoing fusion, or a solution of sulphate of soda in the act of crystallizing, are observed in the dark. The human body itself is not devoid of phosphorescence; in a healthy state it emits a yellow glow, whilst in ill health the colour of the light assumes a reddish tinge. To perceive these phenomena, the eye ought to have been previously rendered sensitive by remaining for some hours in perfect darkness, and even then all eyes are not equally impressionable: if, however, several persons unite in performing the experiment together, there will always be a certain number who are able to perceive the phenomena. Those of our readers who remember the strange announcement made by Reichenbach some years ago, of the existence of a new force in nature, which he termed the odylic force, and have not forgotten the incredulity with which his statements were received, will be disposed to accept any similar observations *cum grano salis*. It must not, however, be forgotten that the propounder of these strange theories is one of the first chemists and physicists of the day, and his researches in this "occult" science are characterized by equal philosophical acumen with his chemical experiments.

The new alkali metals, the discovery of which by Bunsen, by means of "spectrum" observations, we noticed in our last number, have been proved by L. Grandean to be more commonly diffused than was at first imagined. They have been found in Vichy water, in the thermal waters of Bourbonneles Bains, and in many specimens of lepidolite. From the residues obtained in working 100 kilogrammes of this mineral, together with petalite and iriphylline, for the alkali lithia, M. Grandean has prepared considerable quantities of the new alkalies, rubidia, and cæsia. They have likewise been detected in about equal proportions in some residues of the manufacture of saltpetre on a Paris refinery. In similar residues from Belgium saltpetre much rubidia, but no cæsia has been found. Chili nitrate of soda has not, however, been found to yield anything but soda and traces of potash.

Wittstein has verified Tyndall's observation that *pure water* is not colourless but blue. He has also established that the mineral matters which a water may contain do not affect the colour, but that the variety of tints, observed in different masses of water, are due to the presence of organic matter, held in solution by an alkali. He also finds that it may be universally accepted as a rule, that the browner a natural water the softer it is, and that it becomes harder as its colour approaches a pure blue.

A curious action of *silicic acid* has been noticed by J. C. Leuchs. He

finds that silicic acid, precipitated from a water-glass, produces fermentation in saccharine solutions, particularly after the addition of some tartaric acid, and generates the odour of beer yeast, afterwards of fruits, and finally of ether; in very dilute solutions, the odour of putrid yeast appears. Silicic acid does not lose this property by boiling with water, or by repeated employment for fermenting and subsequent washing with water.

The very rare metal *vanadium* has been found by H. Sainte-Claire Deville to be a frequent constituent of clay. In some researches on the mineral bauxite, he found that the colour which was thought to be due to the presence of chromium was, in reality, owing to vanadium. This led to a special search for this rare element, when it was found to be a frequent constituent of clay. It has since been found in clays from the neighbourhood of Paris, from Gentilly, and the refractory clay of Farges-les-Eaux. It seems, therefore, to be well established that vanadium may be found in most clays. Captain Caron has likewise found it in the emerald, in several natural aluminates, and in a very abundant iron ore found in the department of Cher.

The universality of the presence of *arsenic* is receiving stronger confirmation every day. C. L. Bloxam, the discoverer of perhaps the most delicate test for this element, has lately instituted a long series of experiments, in order to obtain sulphuric acid free from arsenic. Starting with the acid of commerce, which always contains arsenic, he successively tried distillation with chloride of sodium, passing hydrochloric acid gas through the boiling acid, electrolysis, fractional distillation, and distillation with oxydizing agents. None of these plans, however, would remove the acid. He then attempted to prepare the acid direct from sulphurous acid by passing a mixture of it and air over platinised pumice stone, but this yielded arsenic. Nitric oxide was then used to oxidise the sulphurous acid, but here arsenic was obtained from both gases. Lastly, he used carefully purified sulphite of soda, as a source of sulphurous acid, and a mixture of sulphate of iron, nitric acid, and sulphuric acid as a source of the nitric oxide. When these gases were prepared at low temperatures, the resulting sulphuric acid was at length found to be free from arsenic. It may be of interest to know that, amongst other bodies containing arsenic, common salt is included.

Silicium, the metallic basis of rock crystal, has been obtained, in a fused state, by H. Sainte-Claire Deville, and also by Captain Caron. It melts at about the fusing point of iron, and can be got in the form of bars and globules. A full account of the physical properties of this substance would be very interesting. At present, however, no full particulars have been made known.

The intensity and persistence of odour of some organo-metallic bodies are remarkable. One of the most striking illustrations which we have ever met with is afforded by a new body, *tellurium-methyl*, recently discovered by Dr. Max Heeren. If a small quantity of this substance is allowed to get on to the finger, it soon communicates a smell to the whole body, and in a few days is perceptible in the breath. The stench is so lasting, that the unfortunate chemist is shut out from society for several months.

II. Applied Chemistry.—We have alluded above to the almost universal distribution of arsenic. A remarkable instance of the presence of this element, in comparatively large quantities, in a drinking water, has recently been published. In the village of Bou-Chater (anciently Utica), there is a warm spring, which contains alkaline arseniates to the enormous extent of four grains to the gallon. The temperature of the spring is 40° C. It is clear, and has no unpleasant taste; the villagers drink it after letting it cool. The water flows from a basin about two yards in diameter. It is confined by stones, and there an old tortoise has taken up his abode, where he has lived from time immemorial, and is looked upon by the inhabitants as the genius of the place. The overflowings of the basin form a stream which, in the absence of a definite bed, spreads on all sides, forming a marsh of considerable extent, covered with rushes, Indian grass, and other plants peculiar to this kind of earth. The inhabitants make use of the stream for washing their linen and sheep's wool, and along the course of it their flocks of all kinds drink habitually. It is supposed that this spring is the same as that mentioned by Cæsar in his "Commentaries" as having such a terrible effect on the army of the Curio. M. Guyon, the chemist, who furnishes the analysis of the water, thinks that the spring was formerly more charged with arsenic than it is at present. It would be interesting for physiologists to study the influence which this water exercises on men and cattle, in reference to the recently raised questions on the economic action of arsenious acid.

The manufacture of saltpetre is being carried on to some considerable extent in America, and native chemical talent is being strained to the utmost to produce it in quantities sufficient to render the Government independent of foreign supplies. It is now being made in the States of Tennessee, Alabama, Kentucky, and Arkansas, from nitrous deposits collected in caves. The crude material of which it is made is a greasy, tough, yellow clay, having a saline taste. The caves in which it is found are very irregular; the best deposits being found in narrow crevices and dry localities amongst the rocks, where there are strong currents of air. It requires considerable experience to select the crude material. There is one establishment near Batesville, Arkansas, in which 1,000 lbs. of saltpetre are produced daily. It is not generally known that, during the previous war with England, saltpetre was manufactured in considerable quantities at the Mammoth Cave in Kentucky.

A curious calculation, of especial interest to makers, has been made by a continental chemist. It is considered, by the most reliable authorities, that the tobacco crop of the whole world amounts to 250 millions of kilogrammes per annum; taking the plant to contain an average of five per cent. nicotine, that would give 12½ millions of kilogrammes of this poison produced annually. The specific gravity of nicotine being a trifle greater than that of water, this quantity would fill 100,000 barrels, and would give 293 grains to every man, woman, and child on the globe. As a few drops will produce death, it is probably much within the mark to say, that the nicotine from one year's crop of tobacco would destroy every

living creature on the face of the globe, if its proportion were administered in one dose.

The repeal of the paper duty has caused a vast number of likely and unlikely materials to be employed in the manufacture of this necessary of civilized life. The curious mineral, asbestos, the long and flexible flax-like fibres of which used formerly to be woven into incombustible cloth, is the most recent ingredient used in paper making. Mr. Audesluys, the proprietor of considerable deposits of asbestos near Baltimore, has introduced asbestos paper in America with some success. From a specimen before us, it would seem well adapted for coarse purposes, owing to its very low price, but it is somewhat friable, although not more so than the commoner kinds of straw paper. The mineral is present to the extent of about thirty per cent., and communicates to the paper a not unpleasant satin-like aspect. It burns with a flame, leaving a white incombustible residue, which with careful management retains the form of the original sheet. Characters written on the paper with ordinary black ink are still legible after burning. Owing to the friability which the presence of this mineral communicates to paper, it would not probably be a useful ingredient in any except low-priced common paper, although it is not impossible that its peculiar property of resisting heat might be of use under some circumstances.

The powerful antiseptic properties of carbolic acid have long been known, but its extended use has been delayed owing to the difficulty experienced in obtaining it in considerable quantities. It is now, however, owing to the labours of Dr. F. Crace Calvert and others, to be obtained on a large scale, and this chemist has been the means of its application to many valuable purposes. As a medical agent it seems to have all the useful properties of creosote in an exalted degree, with some peculiar actions of its own, and is being applied with marked success in the Manchester Royal Infirmary and similar institutions, in cases of chronic diarrhœa, obstinate vomiting (even after creosote has failed), and as a disinfecting wash for ill-conditioned ulcers and gangrenous sores. It has also been applied in cases of foot-rot, which annually carries off large numbers of sheep. As the remedies hitherto adopted in this disease have been only partially successful, these experiments of Dr. Calvert, if they are confirmed in other quarters, will prove a great boon to farmers. The acid has also been applied in the preservation of gelatine solutions and preparations, of size made with starch, flour, and similar materials, and of skins, hides, and other animal substances. It also appears to act strongly as an anti-ferment, and Dr. Calvert states that it is one of the most powerful preventives of putrefaction with which he is acquainted. It is probable also that it may be found to protect timber from dry rot.

The same chemist has been investigating the subject of the preservation of wood in another direction, and has explained why so many of the recently-built gun-boats became rotten whilst others remained sound. The goodness of teak is ascertained to consist in the fact, that it is highly charged with a substance similar to caoutchouc; and it is found that if the tannin be soaked out of a block of oak, and it then be saturated with a solution of caoutchouc, it may thereby be rendered as lasting as teak.

Kœnig likewise has been investigating the same subject; the preservative action of sulphate of copper on wood has long been known, but several anomalies in its action required explanation. It is now found that the retention of copper in the pores of the wood is occasioned by the resinous matter present, those varieties which contain the most resin retaining the most metal; whilst woody fibre from which the resin has been extracted by alcohol fixes no copper whatever in chemical combination. The utility of sulphate of copper as a preservative agent may depend in a great measure on the resinous copper salt which is formed, and by which the pores of the wood are more or less filled up, so that the attacks of insects are prevented.

The valuable properties of *charcoal* as a means of absorbing and destroying the organic impurities in air by being filtered through it, have lately been applied on an extended scale to the ventilation of sewers, by Dr. Letheby and Mr. Haywood. The whole of the sewers in a space of fifty-nine acres in a crowded portion of the east of London have been for eighteen months past connected with the outer air by means of charcoal ventilators. The success of this plan has been perfect. Not only has all stench ceased from the ventilating gratings, but actual observation has repeatedly proved that the odour of the sewer gases is not perceptible when they have traversed the charcoal, and a chemical examination of charcoal which has been in use during the whole of the period shows that the organic *imasurata* is completely changed by its wonderful oxidizing powers into alkaline nitrates. Thus, by the agency of a little wood charcoal, the gaseous emanations of sewage, which the experiments of Dr. Barker, and the clinical observations of Dr. Murchison, have shown to be the cause of a form of continued fever, aptly termed *pythogenic*, are completely arrested on their passage up the ventilating shafts, and changed into perfectly innocuous compounds.

Now that paraffin oils are coming so largely into use, it may be of service to point out a very curious property which they possess. They seem endowed with a remarkable facility for ascending capillary tubes. When placed in a lamp the oil (especially the lighter varieties) rises rapidly on the wick, and flows over the outside, and sometimes even it will creep up the sides of a bottle containing it, and penetrate between the neck and the stopper, escaping into the air. When confined in wooden casks it readily permeates the junctions of the staves if at all unsound, and covers the outside of the barrel. As it is commonly the custom to export paraffin oil in wooden barrels, this property should be well remembered, or serious accidents will occur. It has happened already that in the hold of a vessel, where several hundred barrels of oil were closely packed together, the more volatile liquid permeated the pores of the wood, and mingled with the air, forming a highly explosive mixture, which, on the approach of a light, instantly ignited and set fire to the vessel.

The inalterability under atmospheric and most chemical agencies, which gave to paraffin its name, has been applied to considerable use in the laboratory of the chemist as a lubricant. Nothing is more common, and at the same time more annoying, than to find the stopper of some test-bottle obstinately refuse to move in spite of the different persuasive means

which experience has shown to be useful under such circumstances. By gently warming the glass stopper of a bottle, and then rubbing a little solid paraffin (not the liquid oil) over the contact surface, and afterward moving it round a few times in the neck of the bottle, both being perfectly clean and dry, there will never be any danger of the stopper sticking in its place. The strongest acid or alkaline solutions in ordinary use have no effect upon the thin film of paraffin, which forms the lubricant. Tallow or lard is sometimes used for this purpose ; but owing to the chemical nature of these substances they are soon attacked and rendered useless by caustic liquids, whilst the solutions themselves are injured by the introduction of fatty impurities. Neither of these objections applies to paraffin.

Some interesting experiments have lately been made by M. Maumené, Professor of Chemistry at Rheims, on the aëration of wines by different gases. Ordinary effervescing wine owes its sparkling qualities to the presence of carbonic acid gas, produced by fermentation, and dissolved in the liquid under a pressure of five or six atmospheres. The cork being removed, the greater portion of the gas escapes, communicating to the wine its much-admired sparkling qualities. M. Maumené has prepared wines by forcing oxygen gas into them, under a pressure of seven or eight atmospheres. The wine, when sufficiently old, undergoes no chemical change, even when kept saturated with condensed oxygen for more than a year, and the preparation of the oxygenated liquid is a matter of no difficulty. Wine thus prepared is much more sparkling, or foams more than ordinary champagne. When a bottle is opened it disengages pure oxygen, which rekindles the red-hot spark of a blown-out taper. The taste of the wine is not changed, but it produces, after being drunk, a very sensible warmth, like the better kinds of old wine, and a general and well-marked agreeable sensation. The employment for some days of oxygenated water as a beverage, produces an improvement in the functions of respiration and digestion. A curious result is obtained by charging wine with protoxide of nitrogen (laughing gas), instead of oxygen. The liquid so charged possesses, in a high degree, the power of producing the hilarious effects attributed to the gas itself, it having been found that it was only necessary to drink half a glass of wine, previously saturated with protoxide of nitrogen, at a pressure of six atmospheres, to produce the transitory intoxicating effects attending an inhalation of laughing gas. It is not improbable, that the powerful stimulating properties of oxygen gas, or protoxide of nitrogen, might be of considerable medicinal value, if administered in the convenient form of a daily glass of aërated wine.

New Manganese Dye.—An invention has been provisionally specified, by Mr. P. Morin, of Paris, which consists in the production of a green colour or pigment, by the treatment of oxide of manganese. Protoxide of manganese is transformed into a crystalline transparent substance, and takes a very rich green colour and diamond-like brilliancy when treated with hydrochloric acid in a gaseous state. The pigment or colouring matter thus produced may be applied to painting, dyeing, and the decorative arts, and may also be applied for industrial purposes.

GEOLOGY AND PALÆONTOLOGY.

THE researches of the last two years have done much to prove that man may be regarded as a fossil form of life, as may the mammoth or mastodon. Accordingly, naturalists and geologists are everywhere busy writing our early history.

The fossil bones of man are not yet very numerous, and only one skull can be referred with any certainty to the date of the extinct animals of the Gravel period. It was found in a cave at Engis, near Lüttich, in Germany, associated with bones of the cave bear and other extinct mammals, all in the same state of fossilization, and covered by stalagmite. There is nothing very unusual about the skull except that the forehead retreats from the face with remarkable rapidity. But though this is the only specimen the great age of which is certainly proved, another human skull has been found in a cave at Neanderthal, between Düsseldorf and Elberfeld, which may be quite as old, and which is far more unlike the skulls of existing men. A side view of this specimen is given in Fig. 1 of the adjoining plate; and immediately below it, in Fig. 3, is an outline of the corresponding portion of the cranium of a young Chimpanzee. It can scarcely be necessary to insist on the near resemblance of the two forms. Fig. 2 is a front view of the human skull. In it will be noticed the very prominent ridges over the orbits; though not nearly so much developed, they resemble those of the Gorilla, and are a character commonly associated in old human skulls with a depressed forehead. This human skull is the most degraded form known, and makes the nearest approach to the ape's. Along with it were found a number of other bones; and these, too, differ much from the bones of existing men. The limb-bones are thicker in proportion to their length. This is a feature very characteristic of the higher apes. It also distinguishes the bones of children; so that, as we grow old, we put off the monkey. It is to Professor Shaaffhousen, of Bonn, we are indebted for a description of these remains. Sir Charles Lyell has verified the conditions of the cave in which the former specimen was found. Professor Huxley, remarking on the skulls, says that that from Neandersthal does not differ more from the Engis example than do the skulls of some Australian aborigines one from another.*

An account of another interesting cave exploration is given us by M. Lartet. Near the town of Auvignac, in the south of France, a small hollow on the side of a hill was accidentally discovered by a labouring man to contain about seventeen human skeletons. By order of the then mayor they were removed, and re-interred in the parish burial-ground; and in this translation were found a number of teeth of mammals, which,

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* Although we shall unhesitatingly admit into our pages all reliable information bearing upon the early history of our race, and upon the origin of species, yet we wish it to be distinctly understood that we do not consider the time has arrived for the adoption of any of the contending theories on these interesting subjects.—Ed. P. S. R.

Plate XXI.

Fig 1

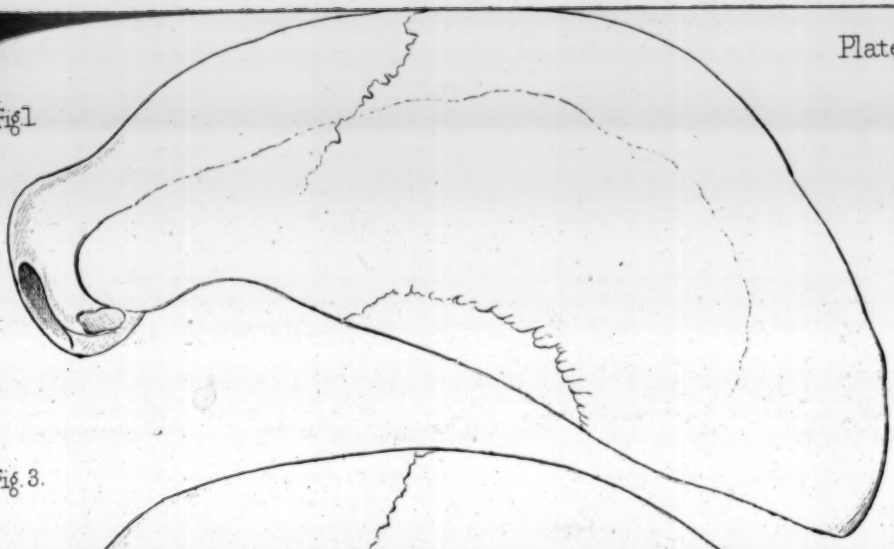

Fig. 3.

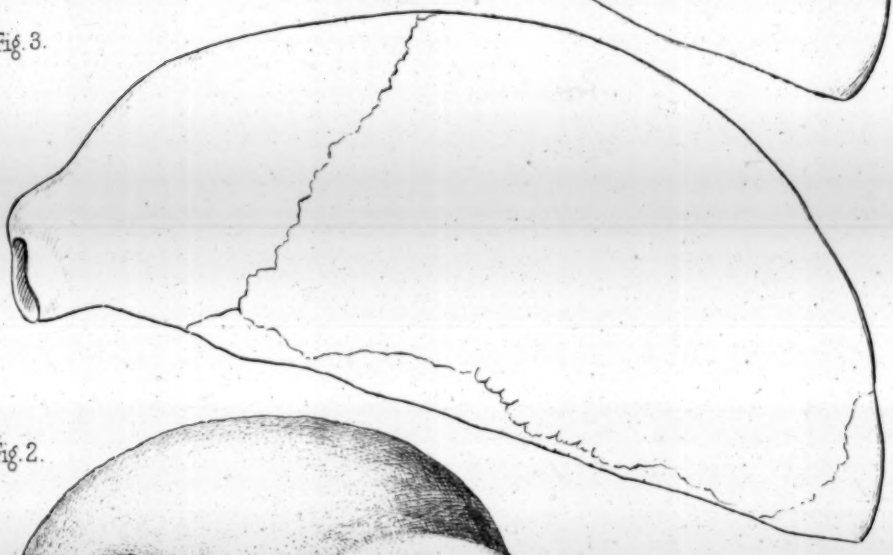

Fig. 2.

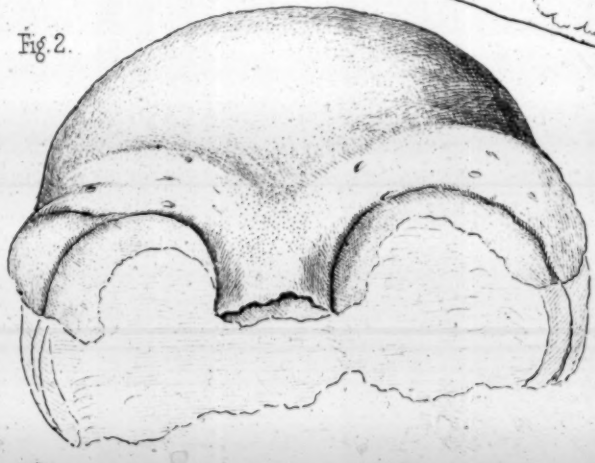

Fig. 4

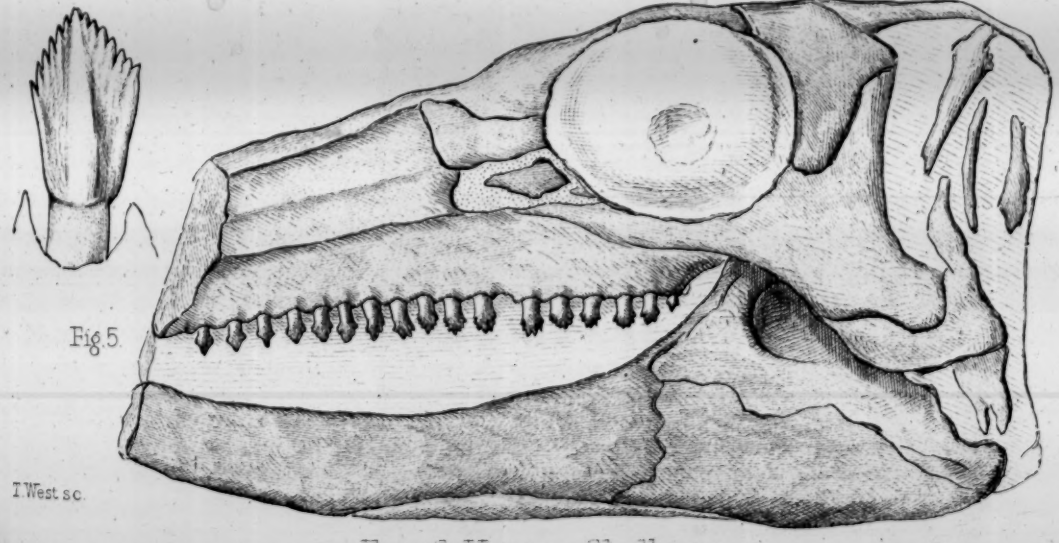

Fig. 5.

T. West s.c.

Fossil Human Skulls, &c.

on being sent to the well-known palæontologist, M. Leymeire, proved to be molars and canines of the hyæna, cave tiger, horse, aurochs, &c. This and other circumstances induced M. Lartet to explore the cave. Its floor and the space on the outside consisted of a deposit of bones of various carnivorous and herbivorous animals, of which most of those in the outer space have been split, as if for extraction of the marrow, and subsequently gnawed; and in the earth among these, various human bones and a tooth were met with, and throughout the mass a number of rude bone and flint weapons. Below all this was a layer of ashes, about six or eight inches thick, which did not extend into the grotto. The base of this old fireplace was made regular by filling in the inequalities, and had a partial paving with thin pieces of sandstone, now burnt red. Among the ashes were found cropolites of the hyæna, and the great bones of the rhinoceros and aurochs, which were split and gnawed, and often reddened and blackened by the action of the fire. Some of the bones have shallow cuts, as though made with the edge of some sharp instrument used to remove the flesh. And, singularly enough, there were found among the ashes a hundred flints, of which the greater number were of the kind called knives;* a few were sling-stones, rendered more than usually destructive by the number of their sharp angles. The part of the grotto in which the skeletons were found was closed by a large stone; and M. Lartet regards the people entombed as those who accumulated the bones, and remarks that none of the animal bones within the cave are gnawed, and were, therefore, probably deposited at successive interments. Be this as it may, there can be but little doubt that the date of the cave is anterior to that of the Amiens and Abbeville gravels, though the conclusion rests on more general principles than M. Lartet advances.

Danish naturalists, as a memoir by Mr. Lubbock tells us, have discovered that in very ancient pre-historic times their country was peopled by a race of Molluscophagi. These people, who used no weapons but rudely-fashioned flints, lived near the seashore, and have left evidence of their existence in deposits of shells so extensive that they were long mistaken for raised sea-beaches. The shells, however, are all full grown, and consist of species which are not naturally found together, being chiefly the oyster, the cockle, the mussel, and the periwinkle; and more rarely the whelk (*Buccinum undatum*), the hedge snail (*Helix memoralis*), and one or two others. Several fish are found; but chiefly the herring, the dab, and the eel. The most common mammals are the stag, the roebuck, wild boar, wild bull, and seal; and with them are found rude flint implements. Many of the bones still bear the marks of knives.† These heaps of refuse are known to the Danes as Kjökkenmöddings, that is, kitchen-middings, which, in fact, they are now proved to be. They vary in thickness from 3 to 5 to 10 feet, are sometimes nearly a quarter of a mile long, and 150 to 200 feet broad. Sometimes, however, instead of being formed about

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* It is interesting to remark that the native Mexican barbers formerly used knives of obsidian to cut their customers' hair and beards.

† Every bone which contains marrow has been broken for its extraction.

villages, they are irregular rings, which have only surrounded a single tent.

At this period the pine was the common forest tree of Denmark; and with it is found the cock of the woods, which feeds chiefly on pine buds. With the heaps occur tumuli, which have supplied numerous skeletons. The skulls are round, and nearly resemble those of the Laps, but have a very prominent ridge over the eyes, approximating them to the form figured in the Plate. The front teeth do not overlap, but meet as do those of the Greenlanders. The age of these makers of the shell mounds is probably much more recent than that of the people of the caves before mentioned, but it still was, even measured by a natural history estimate, a very ancient period, for when these Danes ceased to work flint we find the pine-trees disappearing. These trees were succeeded by oaks, and with them came a race with differently formed heads, workers in bronze. And in their turn the oak-trees die away, and are replaced by beeches; and then comes yet another race of men, workers in iron,—a people whose tumuli tell of a long national existence before the Christian period.

The same divisions of time into the ages of stone, bronze, and iron, which were long ago well defined by ethnologists, have of late received excellent illustration in the explorations of the Swiss lakes. The bones of the men of the stone period as yet found are so few, that all we can say of their forms is that the people had round skulls. The tribes lived in villages on the borders of the lakes, and formed their habitations by driving piles into the bed of the lake. The trees vary in diameter from 3 to 9 inches, and in length from 15 to 30 feet, and some settlements have as many as 40,000. They penetrate into the mud about 5 to 11 feet, and have the lower end rudely pointed by the action of fire, and by stone hatchets. It is not quite certain whether the dwellings were perched on the top of these piles, or whether they floated on the water between them, though the latter condition is the more likely one. The cabins were built on a platform consisting of five layers of trees bound together by interlacing branches and clay. These dwellings appear to have been burnt, and it has so hardened their interior lining of clay, that it has been concluded from large pieces found that they were circular, and from 10 to 15 feet wide. All the species of animals which occur in the lake deposits, excepting the *Bos primigenius*, (the wild bull now extinct), are still found in various parts of Europe, though many have long since disappeared from Switzerland. Imbedded with them are a multitude of fashioned flints and other stones: chiefly hammers, axes, knives, saws, lance-heads, arrow-heads, and corn-crushers. A rude kind of pottery occurs. A few domestic animals are found; and another indication of a civilization in wheaten cakes, and dried apples, and pears.

This stone age is probably of the same date as that of Denmark; the periods which succeed it are not so broadly distinguished from it as are those of the latter country, for the people still continued to build the "pile works" through the "bronze" period into the early part of the age of iron. Most of the remains are now covered by several feet of peat.

We are informed on good authority, that a collector at Woodbridge

has lately obtained from a deep digging in the Red Crag at Ramsholt two horns, which show marks of rude cutting.

In the Lithographic slate of Solenhofen, in Bavaria, Herman von Meyer has found the impression of a feather, which is not to be distinguished from that of a bird. No bones of birds are known of older date than the Cambridge Greensand, in which they are very rare; but the flying reptile, the Pterodactyle, is found in several species in the Bavarian representative of our Oxford Clay.

Professor M'Coy, of Melbourne, has found in the older tertiary deposits of Victoria a species of Trigonia. This genus of bivalve shells, which is one of the most characteristic fossils of the secondary rocks, had not before been found in the tertiary strata, though still living in the Australian seas. In the Silurian rocks of the colony the Professor finds the Graptolites and allied genera existing in many of the species which are found in Wales and Cumberland. And these same forms are found in North America and over much of Europe. Marvellous as so extensive a geographical distribution may seem, it must not lead to the inference that in the earlier ages of the world species were more widely diffused than now; for, at the present day, many of the common forms of similar existing Polyzoan zoophytes, such as Begula nevitina, Ætæa anguina, &c., are found on our own shores, those of Europe generally, along the American continent, in Australia, and in New Zealand.

It is not generally known that the remains of hot-blooded animals, mammals, have been found in the south of England, in a stratum even older than that which yielded the Seelidosaurus. Mr. Moore, of Bath, has found vertebræ and teeth of the Microlestes in a deposit at the base of the lias, called the Rhætic beds, which extend over much of Central Europe. The Microlestes, as will be seen from the figure (4), which is enlarged three times, has the characteristic mammalian dentition in the molar teeth having *fangs*.

Van Beneden has discovered that one of the peculiarities in which some of the Crag whales, such as Squalodon, differed from existing forms, was that they blew the watery vapour obliquely forwards instead of perpendicularly upwards.

The editor of the *Geologist* has figured some globular fossils from the lower chalk as fruits. They appear to have been drilled by the ship-worm (*Teredo*), and yet there is not a trace of structure. In the Cambridge greensand are commonly found spherical and egg-shaped bodies with apertures at the poles, such as there would be in a peeled orange were the central cord partially removed. An imaginative philosopher might make very many species of fruits out of those. They are possibly of vegetable origin.

Professor Ramsay has been investigating the origin of the basins of the Swiss lakes, and he finds that they each lie directly in the path of some great glacier; and, moreover, it is found that these, like the lakes of North Wales, lie in true rock basins, and not in hollows caused by subsidence or upheaval, nor in hollows scooped out by water, nor in lines of fracture; and, so exhausting all other possible causes, he shows that during a period when the glaciers descended lower than they do now these

lakes were hollowed out by the ice. The lakes are deepest at that end nearest the glacier, and in many cases their size and depths were shown to be proportionate to the size of the ice-stream.

Figure 5, is a greatly reduced figure of the Seelidosaurus, briefly noticed in the last number. Nothing further need be added, except to call attention to the reptilian character it shows well, with which most of our readers will be familiar, of having the lower jaw made up of several bones on each side, instead of one as in mammals. The hollow articulation of the lower jaw with the ball in the skull, which contrasts so with the reverse of the structures in the mammal, is unfortunately not shown.

MECHANICAL SCIENCE.

THAT wonderful work of engineering enterprise, the Mount Cenis Tunnel, is at last making satisfactory progress. Its entire length is to be 7·9 miles, and it presents the peculiar difficulty, that from the immense height of the mountain above it, no shafts can be sunk, and the whole has to be excavated at two working faces. At the beginning of last year boring machinery was applied, worked by compressed air; it consisted of eight drilling machines, making 200 strokes of 6 inches per minute; 70 holes about 3 feet deep were thus made in the face of the rock in six hours, and four hours were employed in blasting and clearing away the fragments. According to the latest accounts a new steam-machine has been applied, the invention and manufacture of Messrs. Hawkes, Crawshay, and Co., resembling a small locomotive engine, and carrying a large wheel on which are fixed a series of steel cutters intended to bore auger fashion into the rock, whilst the fragments dislodged are removed by rakes attached to the machine.

During March important experiments were made at Shoeburyness by the committee on iron plates, to ascertain if wood backing could be dispensed with in iron-cased vessels. The target had been constructed for the committee by Mr. Fairbairn, and consisted of 4½-inch armour plates of rolled iron, attached by 2-inch bolts to sheathing plates one inch thick, and these in turn riveted to very strong iron ribs. The armour plates were not dovetailed as in the *Warrior*, but depended entirely on the bolts, which, as the result showed, completely failed, the concussion breaking them in a most extraordinary way. The armour plates were therefore left at the mercy of the shot, buckled forwards, and might have been displaced if the firing had been continued. On the edge of two plates, that is, at the weakest part of the target, three of the heaviest Armstrong shot struck successively on the same spot, and the target was penetrated.

MICROSCOPICAL SCIENCE.

IN offering to the readers of the POPULAR SCIENCE REVIEW a *résumé* of what has been done in microscopical science during the past few months, it must be borne in mind that a selection only can be made from the most

interesting and important discoveries and observations which have been recorded—the crowd of intelligent observers being, on the one hand, so numerous, and on the other the space afforded in these pages being necessarily so restricted.

It will be best, therefore, to adopt as systematic a plan as possible, and we propose to divide the subject of microscopic research into animal, vegetable, and mineral; while any improvements or advances made in the microscope itself will not be lost sight of.

The advantages of the binocular microscope, upon which we dwelt in a previous article, are becoming generally appreciated, and a writer in the *Quarterly Journal of Microscopical Science* (Mr. W. U. Whitney) speaks in raptures of the new views of circulation in a little tadpole unfolded to his sight by the magical instrument. Having ingeniously rendered the little tadpole unusually transparent by a low diet, consisting of *clean* water only, Mr. Whitney was enabled to trace the direction of the course of the larger vessels; and was also favoured with a specimen, unusually transparent, which gave admirable views of its internal economy. We have not space to trace here the whole circulatory system in the tadpole, but wish rather to call attention to the interesting results at which the observer arrives. The first large artery which arises from the heart (the cephalic) supplies the head, but also "receives into it small branches from the subdivisions of the pulmonary artery, so that there is a direct communication between these two vessels." The second (pulmonary) trunk is devoted to the lung, for purposes of aëration solely; and the third (aortic), in its passage to the abdomen, inosculates with the pulmonary branches, and thus provision for aëration is much more completely made than in any reptile. The writer concludes that the liveliness and activity of the tadpole, so superior to that of the adult frog, are owing to this respiratory arrangement, on the well-known physiological principle, that the activity of vital functions is in proportion to the completeness of the aëration of the sanguineous stream which is sent from the heart to all parts of the body.

The changes which the juvenile frog undergoes require indeed active respiration for their normal production. For nine days after the animal is hatched he has external branchiæ like a fish, and requires, in this condition, to be placed in shallow water, not far from the atmospheric air. From the seventh to the ninth day these branchiæ rapidly vanish, first on the right side, afterwards on the left; and then the true tadpole swims apparent. Henceforth he requires atmospheric air for his active respiration. The question whether light or heat most favours the development of these changes forms the subject of a paper read before the Royal Society, by Mr. John Higginbottom, F.R.S., in January last. Numerous experiments, in which the frog's spawn was placed in situations whence light was excluded, led him to the conclusion (contrary to that arrived at by Dr. W. F. Edwards, of Paris) that, the *temperature* being sufficiently high, it mattered not whether *light* were present or absent, the ova developing with equal rapidity in either case. According to Mr. Higginbottom, it is the necessity for atmospheric respiration, rather than the presence of light, which causes the tadpoles to approach the surface, so that experiments, in which the tadpole were immersed in the dark some feet below the surface were altogether inconclusive. Pulmonary respiration takes

the place of branchial; and atmospheric air is necessary, without which the change from tadpole to frog cannot be effected.

We are all, as children, familiar with *spiders' webs*. To some they are objects of terror, to others of curiosity, and to a few, of attractive pleasure. How the little "curious fly" is suddenly arrested when his "gauzy wings" touch that fatal barrier! There is no escape, and out rushes *webspinner* to his dinner. Our friend Mr. Richard Beck has lately paid some attention to the nature of the viscid lines which thus entrap unwary insects, and read a a paper before the Microscopical Society lately, upon that subject. The beautiful regularly-formed webs of the geometric spiders are dotted, except in the closely-packed central fibres, with minute drops, which Mr. Blackwall has calculated the spider to produce at the rate of 200,000 in an hour. Mr. Beck, watching the little architect with a lens, observed that when the thin web left the spinnaret, although viscid, no dots were apparent. More close examination with the microscope rewarded the observer with a sight of the changes which the viscid threads underwent. At first slightly thicker than ungummed threads, the viscid secretion soon began to form undulations, and eventually separated, forming globules, by molecular attraction, at very regular and very minute intervals. Hence, while the wonder of the construction is in no way diminished, the incredible number of these little globules is accounted for by the supervention of a physical law, after the sufficiently marvellous organic law has fulfilled its purpose.

During some microscopic examinations, Mr. Attfield has discovered some new species of acari, which feed upon extract of *nux vomica*. In order to ascertain whether these curious little insects, which greatly resemble cheese-mites, really eat the strychnine, or only lived upon the starchy matter of the extract, some were collected and placed in two cells, one of which contained powdered strychnine, the other being empty. The acari in the empty cell were starved to death in a few days, whilst those with the strychnine were as lively as ever. Other new species of acari were fed upon other poisonous extracts. Those from colocynth thrived equally well on strychnia, colocynth, or cheese, but cheese-mites were poisoned when fed upon strychnine.

But if spiders, with all the wonders of their constructive skill, are, after all, but doubtful favourites, there can be no doubt concerning the attraction which the gay and careless *butterflies* possess for all ages, and for the scientific and the unscientific alike. The delight caused by the magnificence of their wings as they flit about in the sunshine only gives place to wonder when those wings are placed piecemeal under the searching microscope, and the innumerable feathers of which they are composed, far outrivalling in number and brilliancy those of the paradise-bird, gives one a feeling of revelling in the richness and prodigality of bounteous Nature. It would be more proper, in scientific language, to call them *scales* than feathers, for scales they really are, as the term Lepidoptera, or scale-wings, indicates. In the "Annales des Sciences Naturelles" is an article * on the wings of Lepidoptera, by Bernard Deschamps, from which it appears that these scales are composed generally of two or three membranes placed one above the other,

* Translated by Mr. A. G. Latham, and read before the Microscopical Section of the Philosophical Society of Manchester.

on the upper one of which certain granulations are found, which form the colouring matter of the scale, and render it more or less opaque. On the second membrane, striæ frequently exist, consisting of rows of small parallel cylinders, like harp-strings, or lines of pearl-like granulations. Of these striæ there are often one hundred on each scale. The writer believes that there is a *third* membrane in all scales, although it often happens that only two are apparent, owing to the transparency of one of them. In diurnal Lepidoptera this third lamella has the property of reflecting rich and varied colours, more beautiful than those produced by the granulations on the upper membrane. The genus *Vanessa*, and more particularly the exotic species, are particularly enriched from this source; nor are the nocturnal Lepidoptera wanting in this respect, the genera Noctua and Sphynx being examples of brilliantly-coloured insects, though they are far inferior to the diurnal species. The rich metallic blues and greens of some exotic species, such as Ulysses and Paris, arise from a peculiar arrangement of the striæ, the intervals between which are pretty regularly divided transversely into longish squares, each square having within it a funnel-shaped depression. Some scales have the property of dispersing transmitted light in a very beautiful manner under the microscope; and a good example, easily met with, of such scales may be found in the Gamma Moth (*Plusia gamma*), in which these scales may be found forming the pearly or golden bands which are seen below their first wings on the inner margin, starting from the base. The presence of granulations on the upper membrane adds much to the richness of this optical effect. The result of these observations of M. Deschamps seems to be, that "the most brilliant reflections produced by the scales of Lepidoptera are due rather to the *arrangement of their lamellæ* than to the regularity and transparency of their *striæ*."

Professor Unger, of Vienna, has made a curious observation upon some powder from a brick found at Eileithyia, in the Thebaid, Upper Egypt. On examining it under the microscope, he found no less than eight species of plants, of which it was possible still to make out the species, and similar in every respect to species now growing in Egypt and Nubia. The age of this brick being between 3,000 and 4,000 years, it would not appear that that interval has had any marked effect in changing the vegetation of that country.

Mr. Thos. Davies, in the *Microscopical Journal*, has called attention to the unworked field presented by the employment of polarized light—unworked that is to say, in a proper scientific manner; for to many so-called microscopists the exhibition of its pretty effects constitute the whole science, so far as they are concerned.

The most notable contribution to microscopical construction of late has been the universal achromatic microscope of Messrs. Smith and Beck. This microscope, described and figured in the *Microscopical Journal*, has for it first recommendation cheapness—the sum of five guineas bringing it within the reach of many who are separated by an unfathomable abyss from the splendid instruments which would cost almost a year's income to them. An instrument made by the most experienced manufacturers at so low a price is in itself an advantage; but the chief merit in their invention is, that it is susceptible of numerous improvements and additions, which its possessor can, from time to time, make, as his limited funds permit. Thus a body may be

added, to which three eye-pieces and three object-glasses are attached, in such a manner that no labour is lost in setting up the instrument, or in making the necessary changes. A binocular body, with the necessary draw-tubes, may also be added, readily adjustible with little practice ; and, finally, a *stage with actions*, so that the instrument only needs polarizing apparatus, parobolic reflector, lieberkuhn, camera lucida, and micrometer, to make it equal to doing any work which the microscopist may be called upon to perform. In these days of elegance and design, it may be objected that the microscope which possesses these advantages is not so symmetrical as higher-priced ones, but we doubt not that the beauty and completeness of the workmanship will amply compensate for any imaginary deficiencies on that score.

MINERALOGY AND METALLURGY.

Mineral Produce of Italy.—The following valuable information, relative to the mineral produce of Italy, is derived from a report by the commissioners of jurors of the Exposition at Florence :—

Sulphur.—The annual produce of the sulphur mines of Italy is estimated at 300,000 tons, valued at thirty millions of francs. Sicily produces the greatest quantity, while the Romagna produces 8,000 tons.

Iron.—35,000 tons are produced each year. This is all charcoal iron of fine quality.

Lead.—The produce of lead is 7,000 tons. The island of Sardinia alone furnishes 17,000 tons of lead ore (Galena).

Copper.—Annual produce, 1,500 tons, obtained from the mines of Monte-Catini and Capanne-Vecchi, in Tuscany, Agordo, in Venetia, and the Vale d'Aosta.

Boracic Acid.—Two millions of kilogrammes (rather more than two pounds avoirdupois) are produced in Pisa. The works of Count Larderele yield 1,800,000 of these.

Combustibles.—The lignites (wood coal) produced do not exceed 60,000 tons per annum. They have no coal in Italy but the poor anthracite of the Alps.

Nickel.—The nickeliferous pyrites of the Alps yield 50,000 kilogrammes of metallic nickel annually.

Gold.—These pyrites (nickeliferous) also yield, by amalgamation, 500,000 francs in gold per annum.

Mercury.—Tuscany produces 3,500 kilogrammes.

Manganese.—1,000 tons a year are produced from the mines of St. Marcel and Frammura.

Antimony.—Tuscany produces more than 50 tons of antimony per annum.

The Aqueous Origin of Granite.—It is well known that Mr. Sorby, of Sheffield, some years since, called attention to the fact, that the quartz crystals in granite had hollow cavities which contained water. Mr. Alexander Bryson has been pursuing this inquiry, the whole of which tends to support this view. In a paper recently published, Mr. Bryson states his conclusions thus :—

"I found that the quartz of the porphyry of Dun Dhu, in Arran, was full of cavities contained in the doubly acuminated crystals of quartz, for which this remarkable porphyry is distinguished. I also discovered, in the doubly acuminated crystals of quartz formed in the saliferous gypsums of India, thousands of fluid cavities, and the quartz impressed with the gypsum; and as no geologist would hold that this formation was of igneous origin, and as the quartz was impressed by the gypsum, if not contemporaneous, must have been subsequent to it; and, as the same phenomena were exhibited in the porphyry of Dun Dhu, I am forced to the conclusion that the latter was as much aqueous in its origin as the saliferous gypsum from India."

The Gold Deposits of Nova Scotia.—In the month of March, in 1861, a man stooping to drink at a brook observed a small piece of gold among the pebbles at the bottom, and, having picked it up, searched and found other specimens. This occurred at a place about a mile eastward of Tangier river. Gold was subsequently observed in the quartz lodes on the western boundary of Lunenburg harbour; and Mr. Campbell, who commenced washing the sands accumulated on the sea-shore, was eminently successful in finding gold. This led to mining and washing operations on a considerable scale. The result of this has been the discovery of several extensive tracts of metamorphic rocks, in which veins of auriferous quartz abound, and of sands in which gold exists in remunerative quantities. The following are analyses of those two varieties of Nova Scotian gold:—

	Tangier Gold.	*Lunenburg Gold.*
Gold	98·13	92·04
Silver	1·76	7·76
Copper	0·05	0·11
Iron	trace	trace
	99·94	99·91

Meteoric Stone.—In 1857, a meteoric stone was seen to fall near the village of Parnallee, in Southern Hindostan. This stone has been obtained and sent to the Western Reserve College, Ohio. It has been carefully examined by Professor Cassels, who thus describes it:—

"Internally it is a mottled grey colour, having numerous circular spots of pure white. Throughout its recent surface are numerous brilliant specks of nickel, and distinct crystals of nickeliferous iron, with a good deal of iron rust. The meteorite is remarkable for the great amount of nickel it contains, nearly 17 per cent. The magnet abstracts 21·151 per cent. of magnetic iron and nickel from the powdered stone. A careful examination of the stone detected silica, lime, potash, soda, oxide of iron, sulphide of iron, oxide of chromium, oxide of manganese, iron, nickel, cobalt, copper, sulphur, and phosphorus."

The *Bessemer process* of converting crude iron into steel of fine quality at one operation is now acknowledged by its opponents to be a success. From specimens recently exhibited by Mr. Brockbank, it is one of the most plastic and manageable of metals, more so even than copper. It shows a remarkable degree of ductility, and can be bent, flanged, or twisted, either hot or cold, without annealing, and over a considerable

range of temperature, which is not the case with ordinary steel or copper. A plate of 18 inches diameter has been forced through a series of dies until it has formed a tube 13 feet long and $1\frac{3}{4}$ inch diameter, without any crack or flaw. In drilling a circular hole into a plate of Bessemer steel, continuous shavings are formed, whereas in copper, or any other metal, the shavings break into pieces $\frac{7}{16}$ inch long. These sheets of the Bessemer soft steel can be bent backwards and forwards hundreds of times without a fracture, and are almost as flexible as paper.

PHOTOGRAPHY.

WITH so many claims upon the wall-space of the International Exhibition, it appears that the Royal Commissioners have not been able to place at the disposal of intending photographic exhibitors so large an amount of accommodation as will fully satisfy all demands. They have devoted, however, no less than three thousand square feet to the exhibitors in this department; and we may confidently anticipate that the forthcoming display will contain the choicest results, and be characteristic of our English operators. M. Claudet, as the exponent of the opinions of a large section of our most distinguished artist photographers, has addressed a letter to the Council of the London Photographic Society, wherein he advocates the policy of organizing, without delay, an independent exhibition for the reception of such works as are necessarily excluded from the International building at Kensington, but which, if collected, would constitute in themselves a very complete and interesting supplementary gallery, likely to possess great attraction for a numerous class of visitors to the metropolis during the coming season. Independently of M. Claudet's suggestion, a committee of the South London Photographic Society have already announced the terms of a mutually advantageous arrangement which they have entered into with the Directors of the Crystal Palace Company. If this scheme can be carried into effect at Sydenham, it is proposed to devote a large space in the first gallery, immediately adjoining the central transept, to the purpose of a British and Foreign Photographic Exhibition; and in recognition of the efforts of those who contribute to this collection, it is intended to present to each exhibitor a season ticket, available for six months from the period of inauguration, which is provisionally fixed for the 15th of May.

Since the period of the last report, M. Joubert has accomplished much towards perfecting his process for transferring photographs to glass and porcelain. Some of the photo-enamels which that gentleman exhibited on a recent occasion were unexceptionable as works of art.

Great progress has lately been made also in the production of transparent photographs upon glass slides, suitable for exhibition in the oxy-hydrogen lanterns. Mr. England employs a dry-collodion process in which tannin is the preservative agent, and prefers the use of a solution of sulphate of iron for developing the image. The magnified representations of street-scenes in Paris are remarkably true to nature, from their having been the result of instantaneous exposure; and the pictures which Mr. England has taken of the Niagara Falls, and other famous illustrations of American scenery, are also highly successful, whether examined in the stereoscope or projected upon a screen.

The later results of Professor Graham's important discoveries in *dialysis*, which have reference to the differences observed in the passage of various liquids through porous membranes, have placed in the hands of practical photographers a new and valuable instrument. The dialysis will serve a useful purpose in effecting the separation of salts from highly-charged albumen and other liquids of a glutinous nature; it is only necessary to expose these mixtures for a short time to the action of pure water outside the diaphragm, when it will be found that the saline constituents have passed through the animal membrane, or the so-called vegetable parchment, without any appreciable loss on the part of the albumen. So complete is this separating action, that it has been suggested to employ such means in the analysis of compound photographic preparations.

Improvements in the construction of photographic apparatus have resulted in the manufacture of cheap and efficient *rolling presses*, by the aid of which a very superior surface may be imparted to paper in the form of the finished proof, or in any intermediate stage. Messrs. Bury Brothers, of Manchester, have succeeded in greatly reducing the cost of these machines, so that they are now likely to come into general use, and enable the photographer to dispense with the practice of sending away the proofs to be milled.

The construction of the Camera itself is likely to undergo alteration in respect to placing the means of adjustment for focus in front, instead of the usual sliding arrangement being worked from the back. Many contrivances have been suggested; among others, that proposed by Mr. Window possesses the advantage of rigidity from the circumstance of the dark slide entering that portion of the camera-body which is firmly clamped to the tripod stand. The ground glass is also permanently attached to the back of the camera.

Mr. Crookes has reported upon the comparative efficiency of a substitute for orange-glass. Muslin or other light textile fabric is coated with glue in order to close the interstices, and form a continuous layer of sheet gelatine; this being submitted to the action of a weak solution of nitrate of silver, and then exposed to the light, forms a compound which is impervious to all but the yellow rays, and being tolerably permanent and insoluble, is susceptible of application for laboratory windows and similar purposes. The facts which stand opposed to its general introduction is the brittleness, which unfits it for rough exposure, and the tendency to air-bubbles in the glue giving rise to small pin-holes in the fabric.

The announcement of a *new photographic process* by Mr. Emerson J. Reynolds, of Dublin, has given rise to much discussion, and to the assertion of counter claims of priority. Sir John Herschel, Mr. Burnett, Dr. Phipson, and others, appear to have employed the oxalate of peroxide of iron as a chemical agent, which suffers reduction to a proto-salt on exposure to sunlight, and is capable therefore of a photographic application. Mr. Reynolds proposes to develop upon paper the result of such exposure by treatment afterwards with ammonio-nitrate of silver, when a picture will be formed by the dark reduced silver partaking of the general character of a photographic negative. Sir John Herschel preferred chloride of gold for developing the image; and Dr. Phipson endeavoured to dispense with the use of silver by employing pyrogallic acid in conjunction with the permanganate of potash.

ZOOLOGICAL.

THE earth, air, and sea, are peopled with inhabitants, to which systematic zoological works may be regarded as so many directories containing their names and addresses. But so numberless are their denizens, that it can be no matter of surprise that many should be overlooked and omitted from the earlier editions; so that a running supplement becomes necessary, to receive the names of new visitors which from time to time reveal themselves to the prying eyes of intruding zoologists, who scour over untrodden deserts, watch in lonely solitudes, and scrape the bottom of the deep sea, in the hope of bringing to the light of science some retiring creature which has hitherto eluded the inquisitive gaze of the ardent naturalist. Such running supplements are numerous, and are enriched by the labours of workers in many countries and in many departments; and it is proposed that the present article, and those which succeed it, should serve as an index to these supplements—bringing under the reader's attention the most notable of the distinguished strangers which are thus unwillingly and unwittingly rescued from the fate of "blushing unseen."

It might naturally be expected that the additions thus made to our knowledge of the animal inhabitants of the globe, after so long periods of research had passed by, should consist chiefly, if not exclusively, of the *smaller* terrestrial animals. There are, however, some large tracts of the earth's surface so little explored by the European, that we cannot assert that terrestrial animals equalling, or even surpassing, in size those with which we are acquainted, do not exist. Thus, circumstances have recently occurred which render it a matter of high probability that a colossal bird similar to the Dinornis, if it be not the Moa itself, still roams about in the district of Nelson, in New Zealand. The Government surveyors have more than once come upon footsteps which struck them with as much astonishment as did that of Friday surprise the solitary Robinson Crusoe—footsteps whose length was fourteen inches, and spread eleven inches, while the stride measured thirty inches; and this has happened under circumstances which left no doubt in their minds of their being but a few hours old. Erelong it may be hoped that we shall hear of the restoration of one of the marvellous and romantic links which connect us with an elder world.

But while we may feel surprise that such vast creatures, treading the same solid earth with ourselves, should have so long escaped us, we can feel no wonder that the boundlesss sea should yield from time to time new marvels stranger than those we are yet acquainted with. As Spenser exclaims, in the "Faëry Queene,"

"So fertile be the floods in generation!"

while a common proverb tersely expresses the same fact, which says that "there are stranger fish in the sea than ever came out of it." The great sea-serpent is still a *vexata quæstio;* and while so much can be said by naturalists on both sides, it must inevitably be held to remain *sub judice.* The most remarkable sea-monster which the "unfathomed caves of ocean" have

cast up to the light of day for some time past, was an enormous cuttle-fish observed by the crew of a French ship of war, the *Alecton*, about 40 leagues N.E. of Teneriffe. This monstrous cephalopod was 15 to 18 feet long, with eight arms 5 or 6 feet long covered with suckers, eyes of enormous size, and *beak* 18 inches in diameter. It was estimated to weigh 4,000 lb. Unfortunately, it was not secured, although wounded and seized with a harpoon. As a balance against these vast additions to the Fauna of our globe, we must strike out one of the most considerable of our quadrupeds from the roll. In the year 1854, the indefatigable Dr. Gray, of the British Museum, described the horn of a rhinoceros, which was so remarkably curved, and so different from the horns of known species, that he founded upon it a *new* species, which he called *R. Crossii*. That excellent Indian zoologist, Mr. E. Blyth, has recently discovered, however, that the extraordinary horn in question is but the "well-developed anterior horn of an old male *Rhinoceros sumatranus*, the common species of these provinces" (Maulmein). So that the number of species of these great pachyderms must be reduced by the erasure of *Rhinoceros Crossii* from the list.

There is no division of the animal kingdom to which more numerous and systematic accessions are constantly being made than to the various orders of insects. It could not be otherwise, when we bear in mind the vast proportion which the insect world bears to the other divisions of animals. The insect collector has many things in his favour: there is endless variety, and endless novelty; no fear of exhausting the subject, and comparatively little labour in the preparation of his specimens. It thus happens that insect collectors, both in this and in foreign countries, are numerous and successful. Mr. H. W. Bates, the indefatigable collector in an inexhaustible field, continues to enrich science with his lists, the latest being that of Longicorn beetles in the valley of the Amazon. Angola, too, has yielded some new beetles belonging to the same division; and to the Weevils other collectors have swelled the lists in their respective departments—as for instance the fertile discoveries of Mr. Adams, among the Mollusca of the Sea of Japan, have most recently added many new species to the Acephalous division, as well as a long list of Opisthobranchs, belonging to the families Cyichnidæ, Bullidæ, and Phylinidæ; while Mr. J. Yate Johnson has carefully systematised the Sea-anemones of the neighbourhood of Funchal, the capital of Madeira, adding six new and remarkable species from his own researches.

But the additions to the British Fauna should not be passed over in silence, and we will briefly state, in conclusion, what new inhabitants of our own islands have recently come to light. The pages of the "Zoologist" faithfully record the occurrence of unusual visitors, chiefly birds, to various parts of these islands. Among them is mentioned a species of goat-sucker (*Caprimulgus ruficollis*), killed some time since near Newcastle. Dr. Gray announces in the "Annals" the addition to the British collection of the rare fish, *Diodon pennatum*, caught near Charmouth; and the second specimen found on these coasts. A continental beetle (*Eustica plicata*) has been met with at Stockwell; and new additions to the Lepidopterous Fauna are not unfrequent,—species of Gelechia, Tinea, and other insects, which will be, no doubt, duly collected and recorded by Mr. Stainton, in

the *Entomologist's Annual.* Several new Entomostraca, inhabiting chiefly the Firth of Clyde, and belonging to the genus Cythere, have been described by the Rev. A. M. Norman; as well as fresh-water species of Cypris and Candora from ponds in Durham. Dr. John Anderson describes and figures in the "Annals," a new species of *Holothuria*, dredged in Bressay Sound, Shetland, at five fathoms; and the same observer has systematised the genus *Sacculina*, which is found parasitic upon crabs, describing one species, *S. triangularis*, which he finds commonly upon the edible crab (*Cancer Pagurus*) of the Firth of Forth. Against all these additions, also, must be deducted a fresh-water mollusc (*Physa acuta*), lately described as having been met with in a brook near Bushy Park, the presumed discoverer of which, however, now candidly confesses it to have been an error.

Before closing this *résumé*, we would call attention to the valuable catalogue of the Zoophytes of South Devon and Cornwall, now in course of publication by the Rev. Thomas Hincks, of Leeds, in the "Annals of Natural History." The subject of British Zoophytology is one which needs careful revision, and we regard these papers as of great importance, and look forward with pleasure to the forthcoming work on British Zoophytes, which the same gentleman is preparing.

POSTSCRIPT.

Since our Astronomical Summary was completed we received from Mr. G. F. Chambers an account of the discovery of a new minor planet by Dr. C. H. Peters, of Hamilton College, Clinton, New York. It will take the number seventy-one (Niobe, discovered in August last, becoming seventy-two), inasmuch as it was discovered in May last, although only now made public. The same correspondent also announces the discovery, by Mr. A. Clark, optician, Boston, F.S.A., of a new star, a companion to Sirius. This was made with an improved instrument, which is likely to aid in the development of astronomical research.

We are compelled most reluctantly to defer the insertion of Professor Ansted's second paper on Caverns.